US009893419B2

(12) United States Patent
Yosui et al.

(10) Patent No.: US 9,893,419 B2
(45) Date of Patent: Feb. 13, 2018

(54) ANTENNA DEVICE AND COMMUNICATION TERMINAL APPARATUS

(71) Applicant: **Murata Manufacturing Co., Ltd.**, Nagaokakyo-shi, Kyoto-fu (JP)

(72) Inventors: **Kuniaki Yosui**, Nagaokakyo (JP); **Naoki Gouchi**, Nagaokakyo (JP); **Naoto Ikeda**, Nagaokakyo (JP); **Hiroyuki Irikawa**, Nagaokakyo (JP)

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 226 days.

(21) Appl. No.: **14/604,940**

(22) Filed: **Jan. 26, 2015**

(65) **Prior Publication Data**

US 2015/0138030 A1 May 21, 2015

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2014/070366, filed on Aug. 1, 2014.

(30) **Foreign Application Priority Data**

Aug. 2, 2013 (JP) 2013-161825
Dec. 4, 2013 (JP) 2013-250844
(Continued)

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 7/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/52*** (2013.01); ***H01Q 7/00*** (2013.01); ***H01Q 7/06*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/38; H01Q 1/52; H01Q 7/00; H01Q 7/06
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,289,069 B2 * 10/2007 Ranta H01Q 1/243
343/700 MS
2001/0024739 A1 9/2001 Mizoguchi et al.
(Continued)

FOREIGN PATENT DOCUMENTS

JP 06-334289 A 12/1994
JP 2001-244123 A 9/2001
(Continued)

OTHER PUBLICATIONS

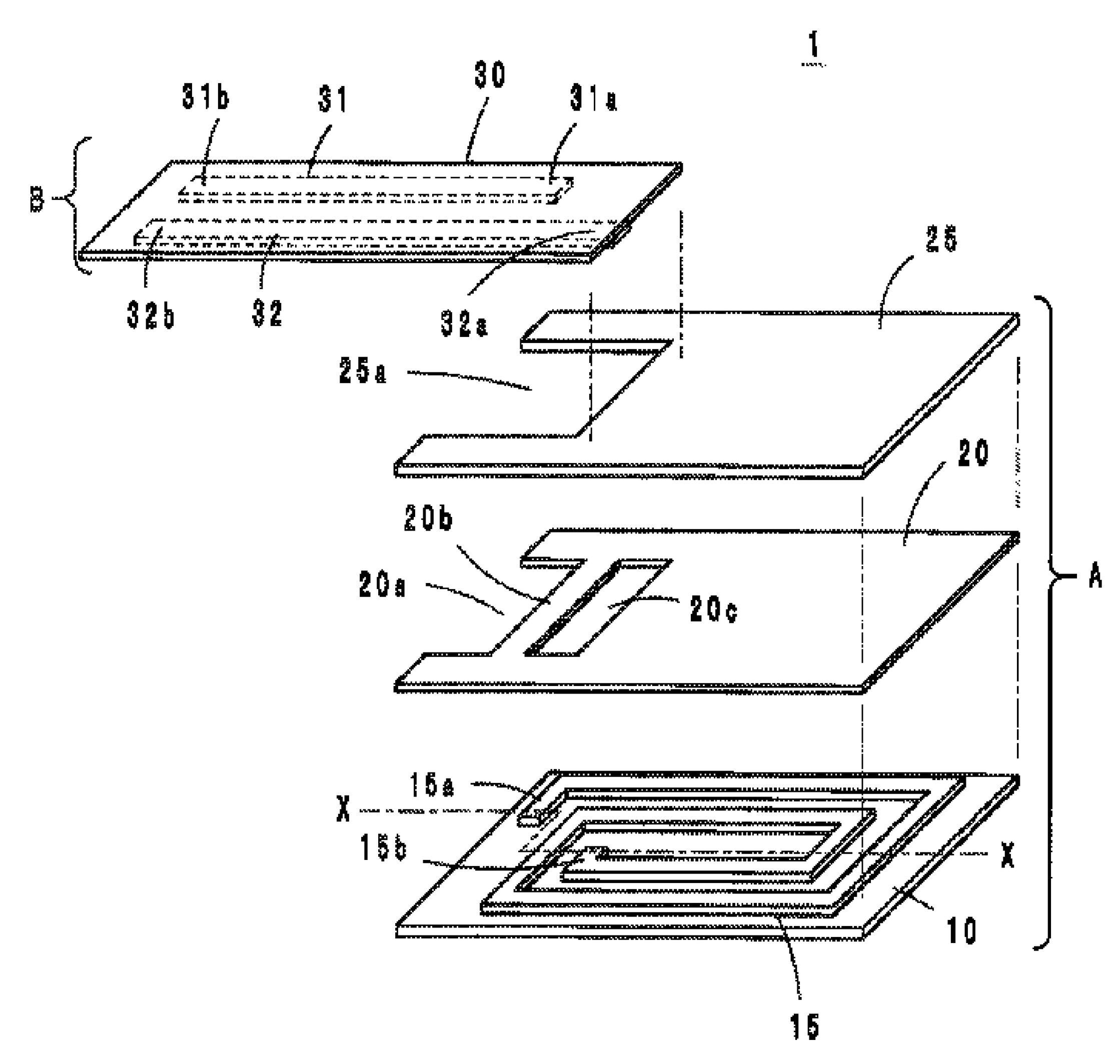
Official Communication issued in International Patent Application No. PCT/JP2014/070366, dated Sep. 2, 2014.
(Continued)

Primary Examiner — Hoang Nguyen
Assistant Examiner — Jae Kim
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

An antenna device includes a first insulating base portion including a spiral antenna pattern, and a second insulating base portion including at least two conductor wires. An insulating layer configured to insulate the conductor wires from the antenna pattern is provided between a first end and a second end of the antenna pattern in a planar view. The insulating layer includes a cut or an opening allowing at least one of the first end and the second end of the antenna pattern to be exposed toward the conductor wires. Electrode portions of the conductor wires are electrically and mechanically connected to the first end and the second end, respectively, of the antenna pattern by a conductive material in the cut or the opening of the insulating layer. The second insulating base portion is more flexible than the first insulating base portion.

20 Claims, 28 Drawing Sheets



(30) **Foreign Application Priority Data**

Feb. 17, 2014	(JP)	2014-027091
May 9, 2014	(JP)	2014-097316

(51) **Int. Cl.**

H01Q 7/06	(2006.01)
H01Q 1/52	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0047737	A1	2/2008	Sahara et al.		
2010/0182144	A1	7/2010	Yamashita et al.		
2012/0105362	A1*	5/2012	Kremin	G06F 3/03545	345/174
2015/0077296	A1*	3/2015	An	H01Q 1/22	343/720

FOREIGN PATENT DOCUMENTS

JP	2001-284759	A		10/2001	
JP	2004-266811	A		9/2004	
JP	2008-34588	A		2/2008	
JP	2008-205557	A		9/2008	
JP	4218635	B2		2/2009	
JP	2010-288242	A		12/2010	
JP	2012-109406	A		6/2012	
JP	2012-134656	A		7/2012	
JP	2012203602	A	*	10/2012	
JP	2013-013144	A		1/2013	
WO	2008/018413	A1		2/2008	
WO	WO 2013/141658		*	9/2013	H01Q 1/22

OTHER PUBLICATIONS

Official Communication issued in corresponding Japanese Patent Application No. 2014-553560, dated Sep. 29, 2015.

* cited by examiner

FIG. 1

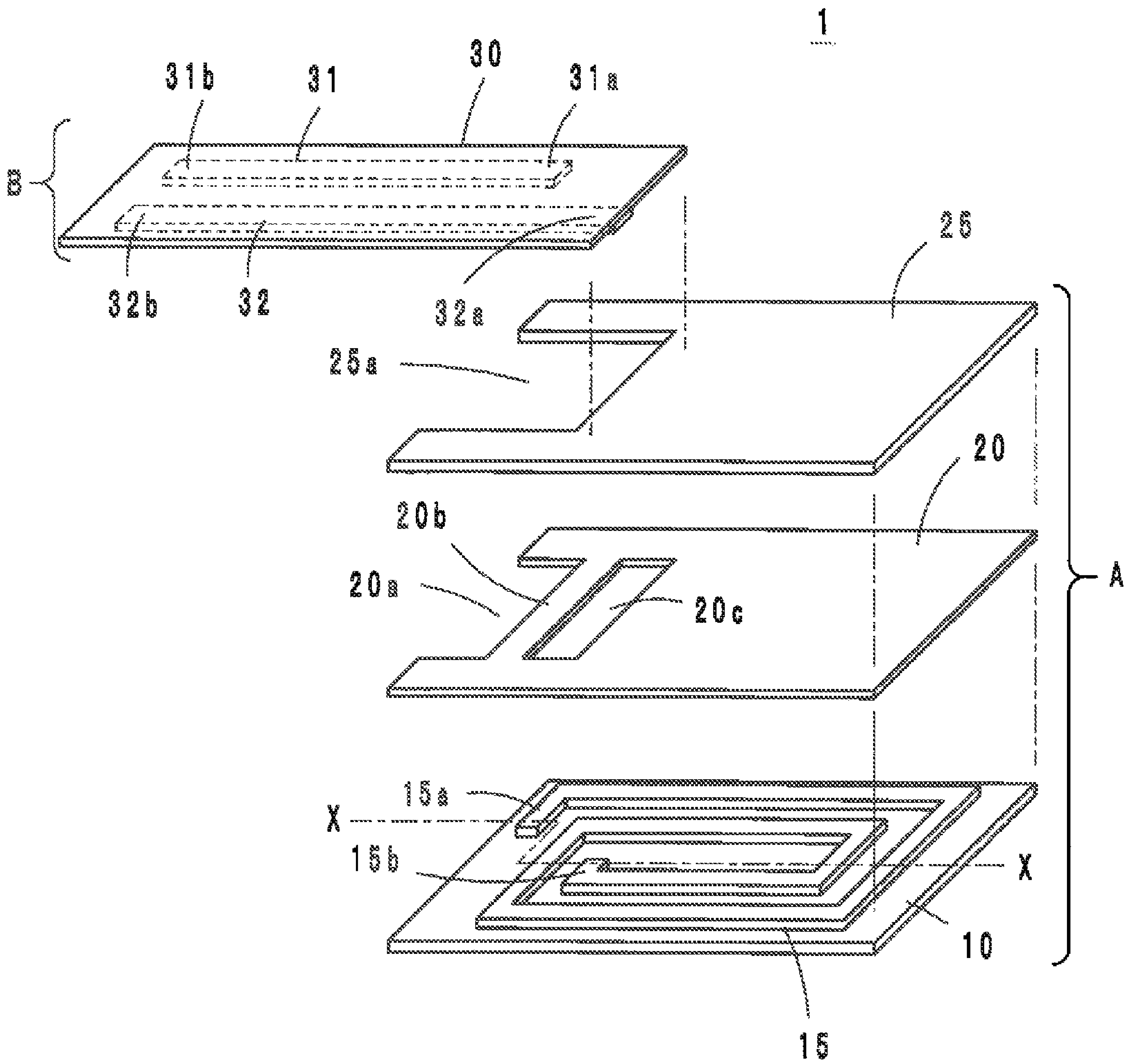


FIG. 2A

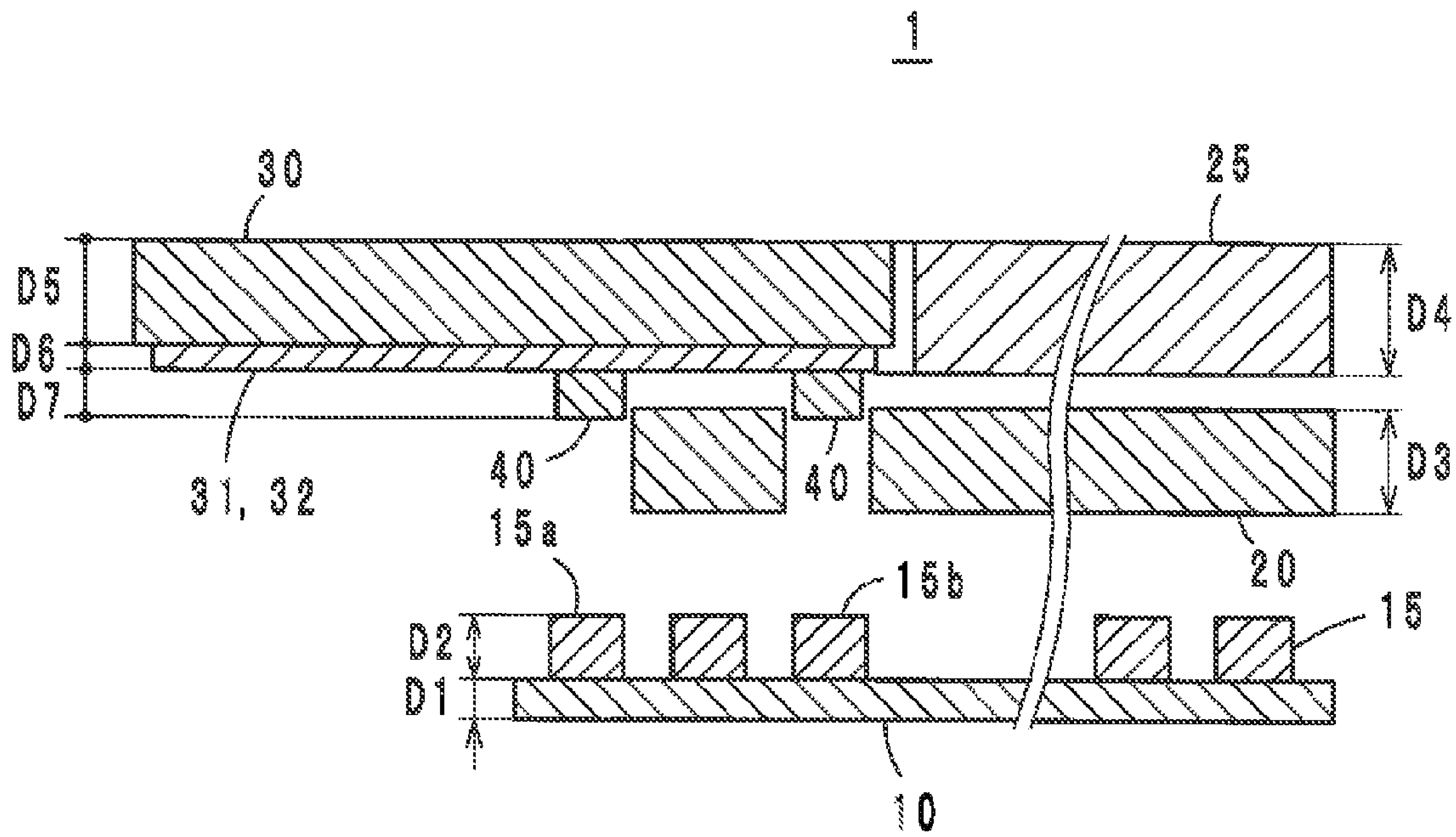

1
30
25
D5
D6
D7
D4
D3
31, 32
40
40
15a
20
15b
15
D2
D1
10

FIG. 2B

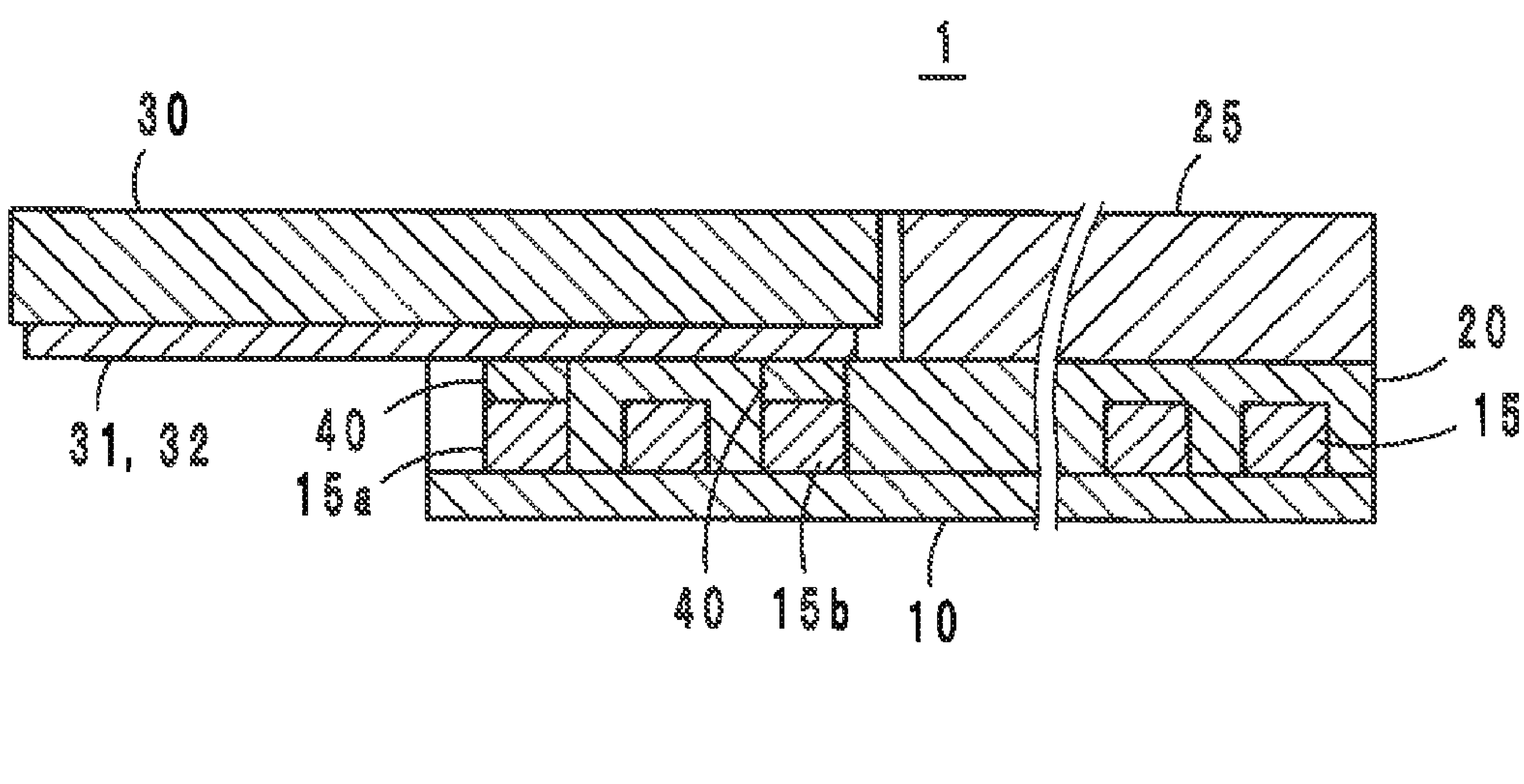

1
30
25
20
40
31, 32
15
15a
40
15b
10

FIG. 3

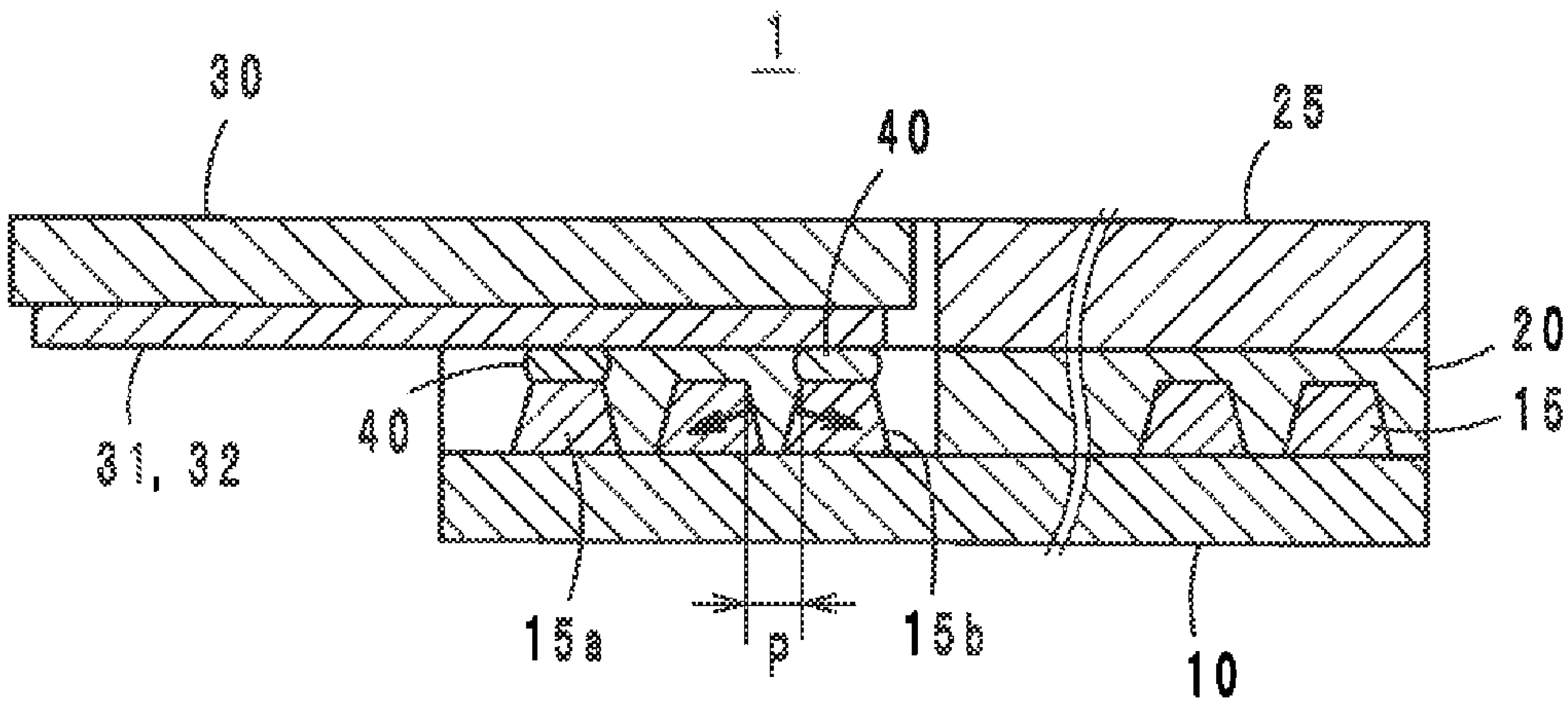


FIG. 4

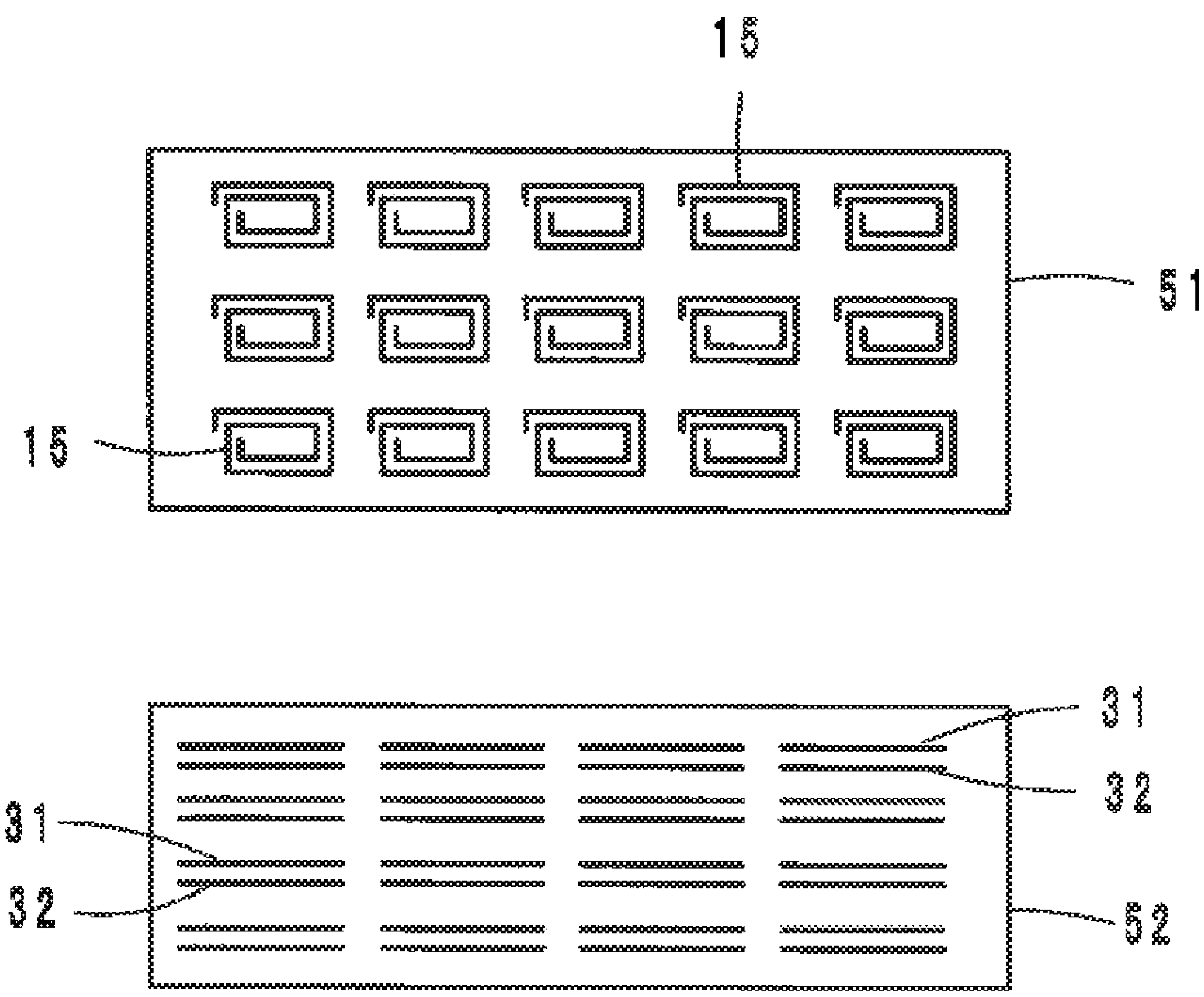


FIG. 5

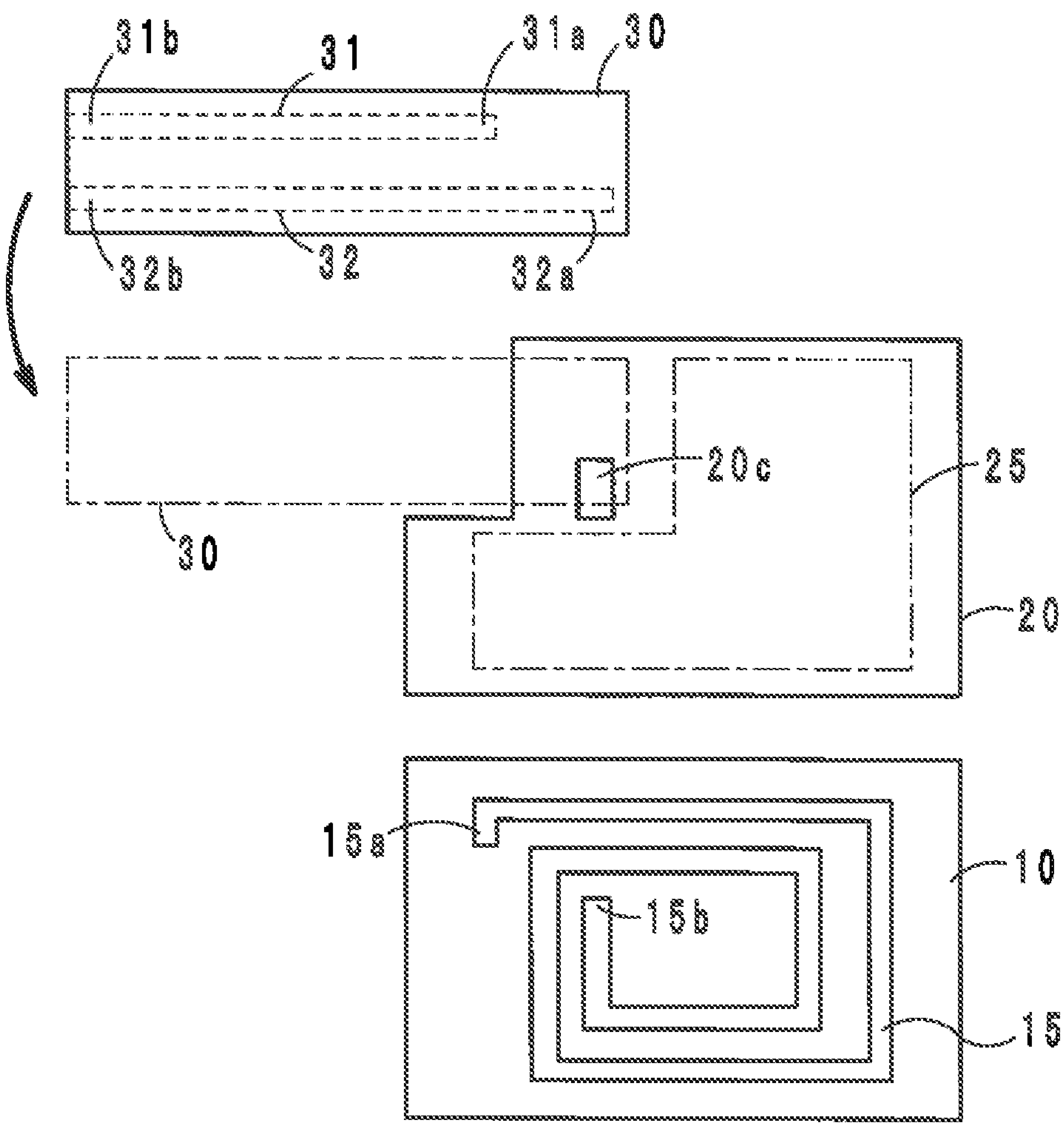


FIG. 6

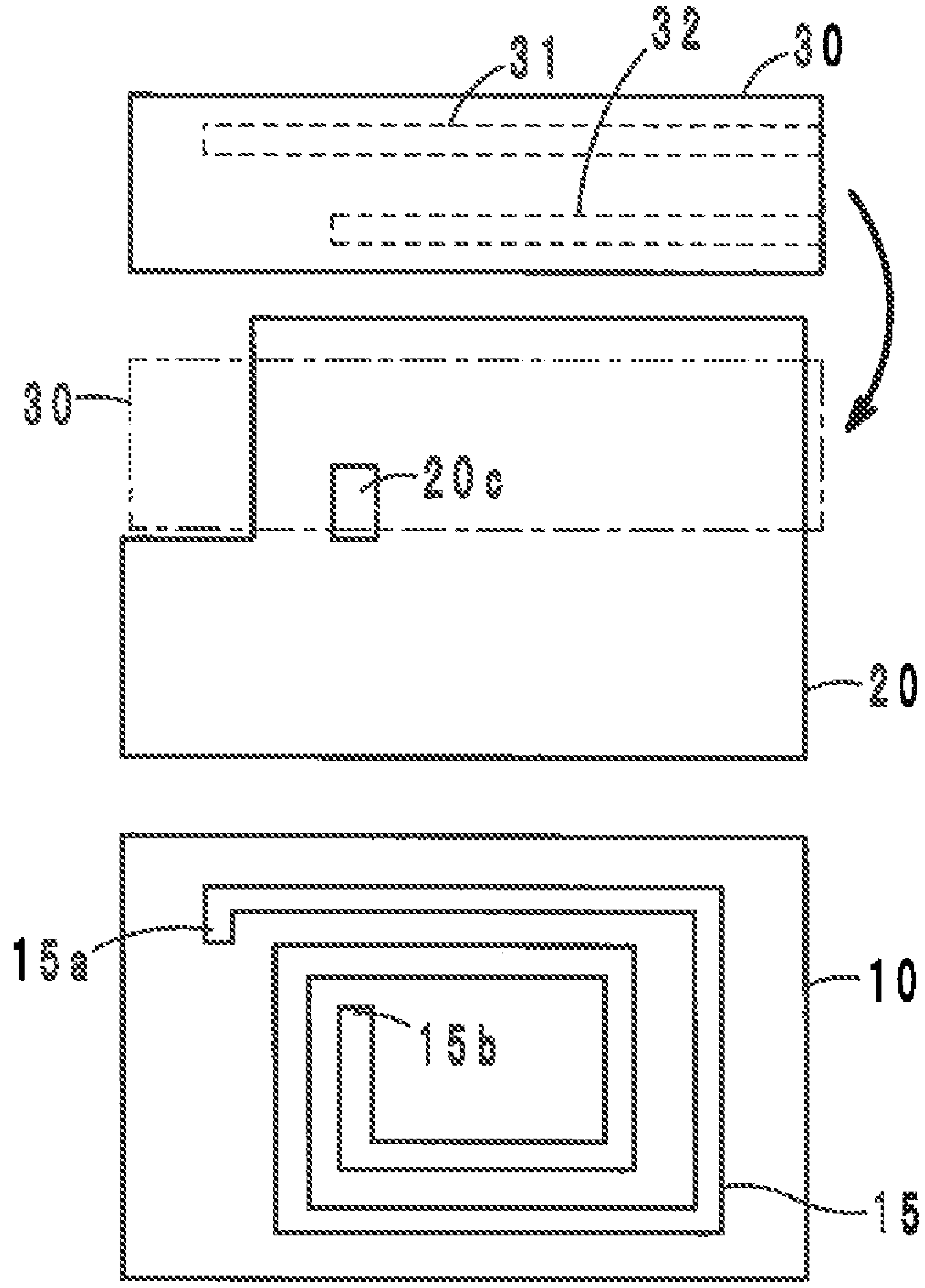


FIG. 7

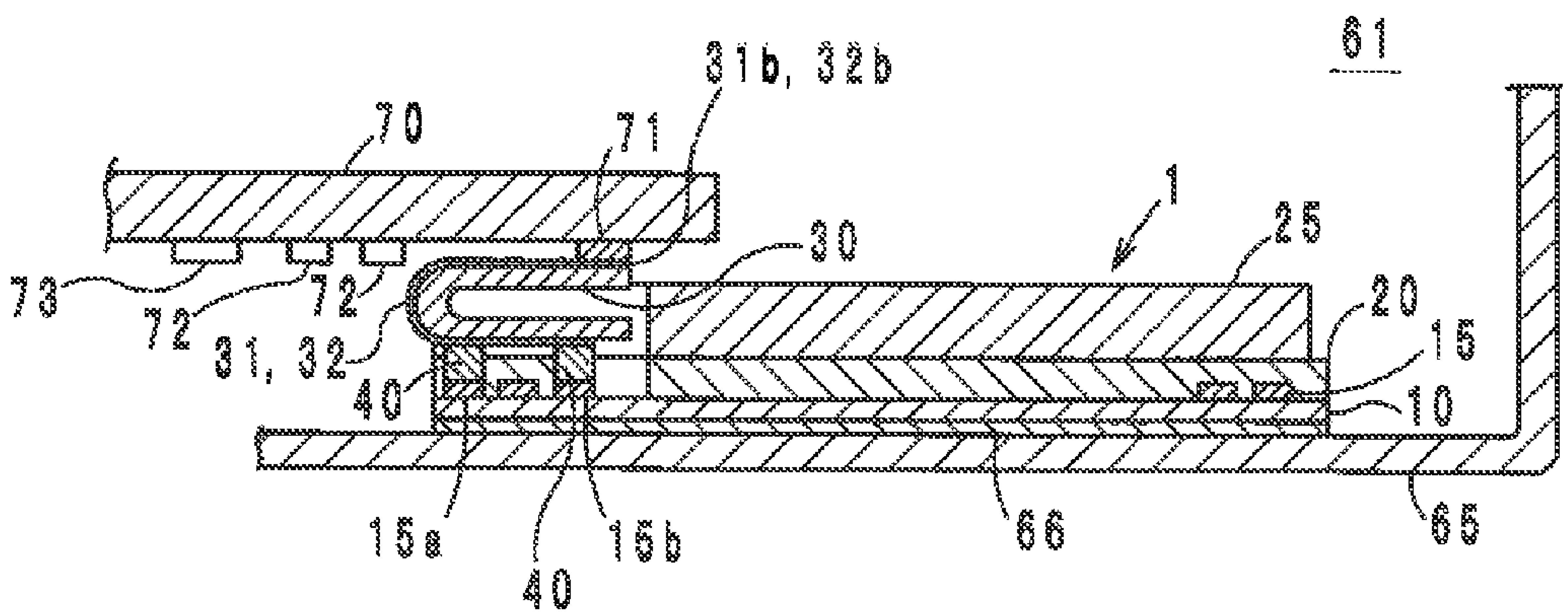

61
31b, 32b
70
71
1
30
25
73
72
72
31, 32
20
15
40
10
15a
40
15b
66
65

FIG. 8

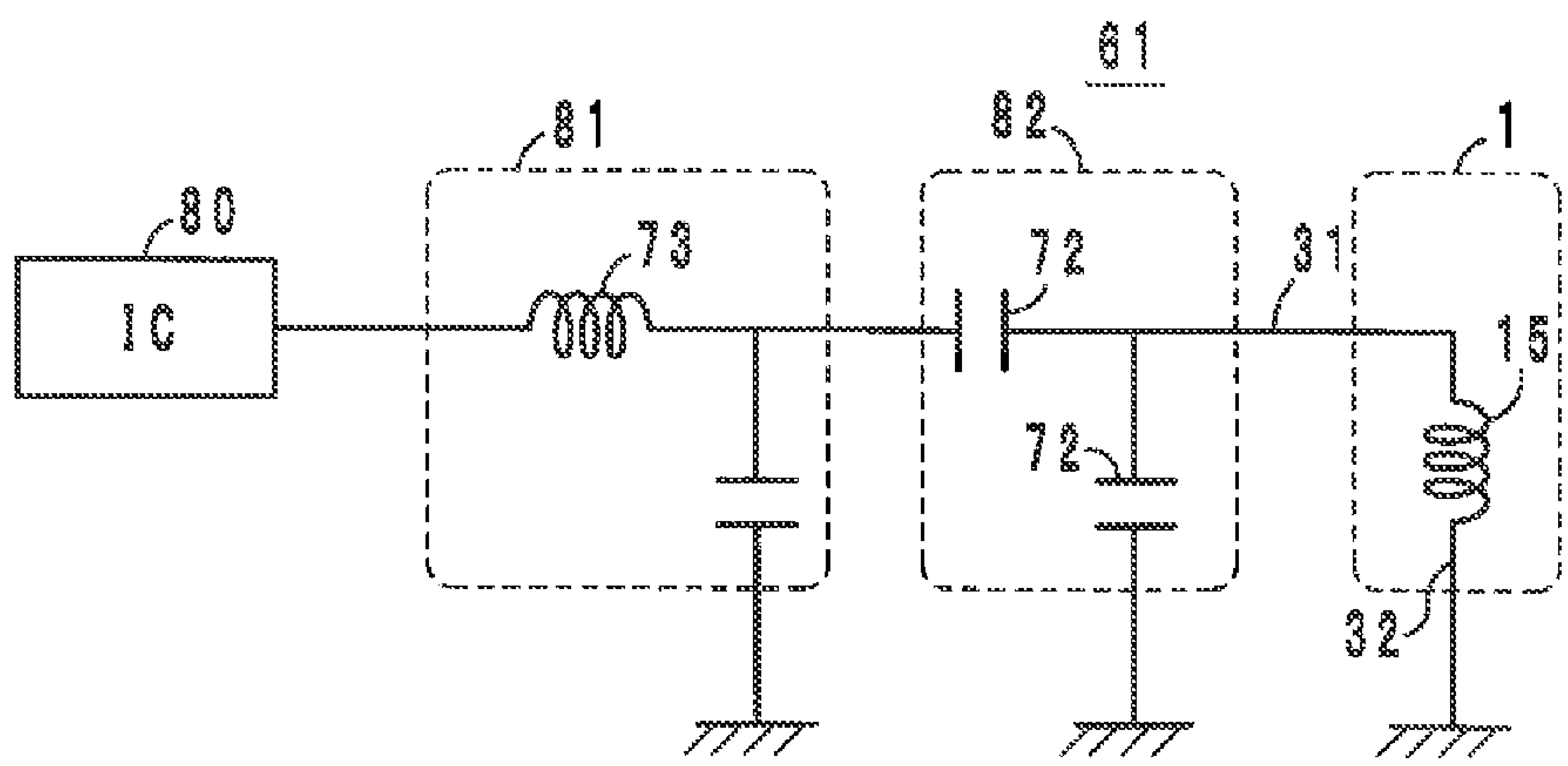

61
81
82
1
80
IC
73
72
31
15
72
32

FIG. 9

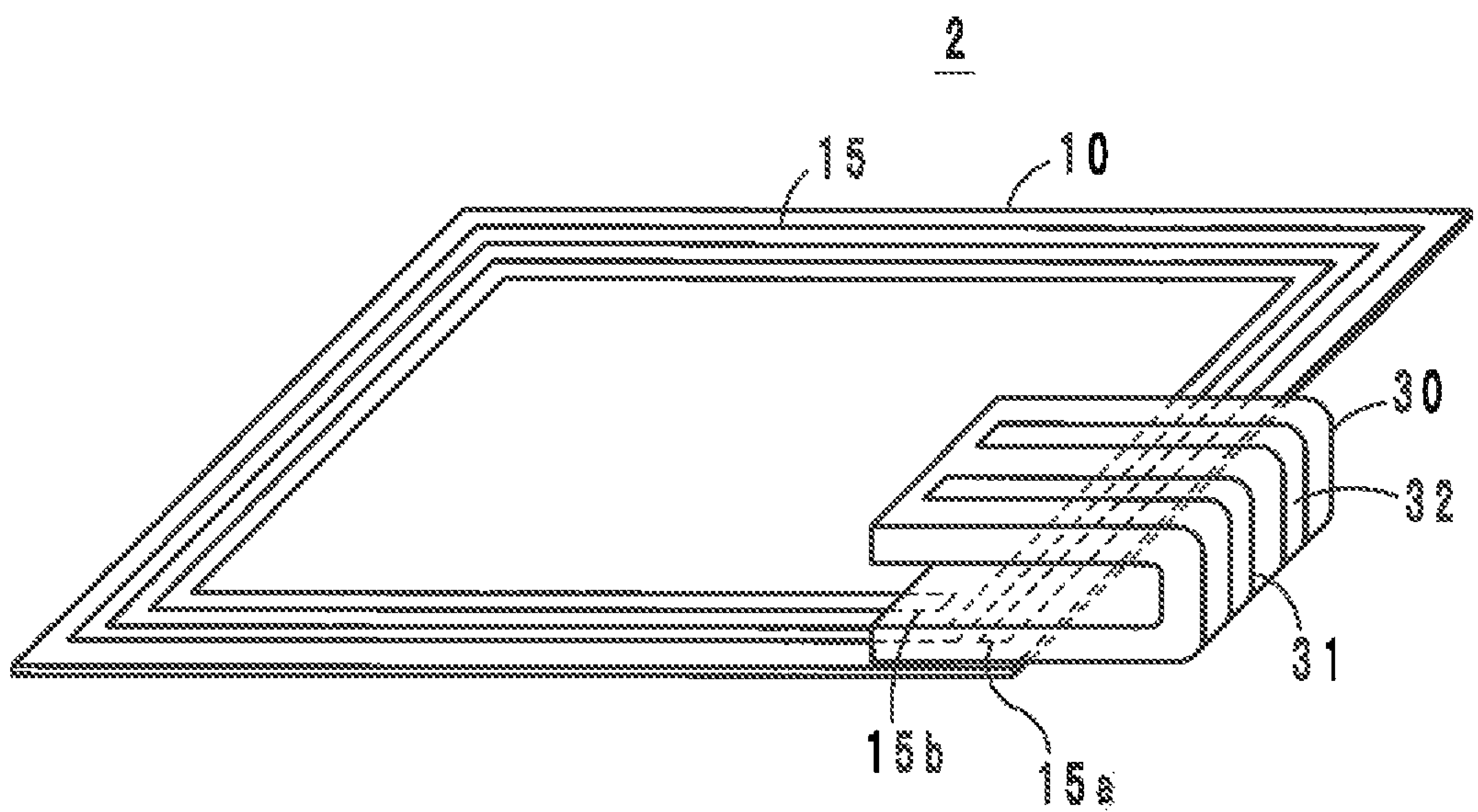
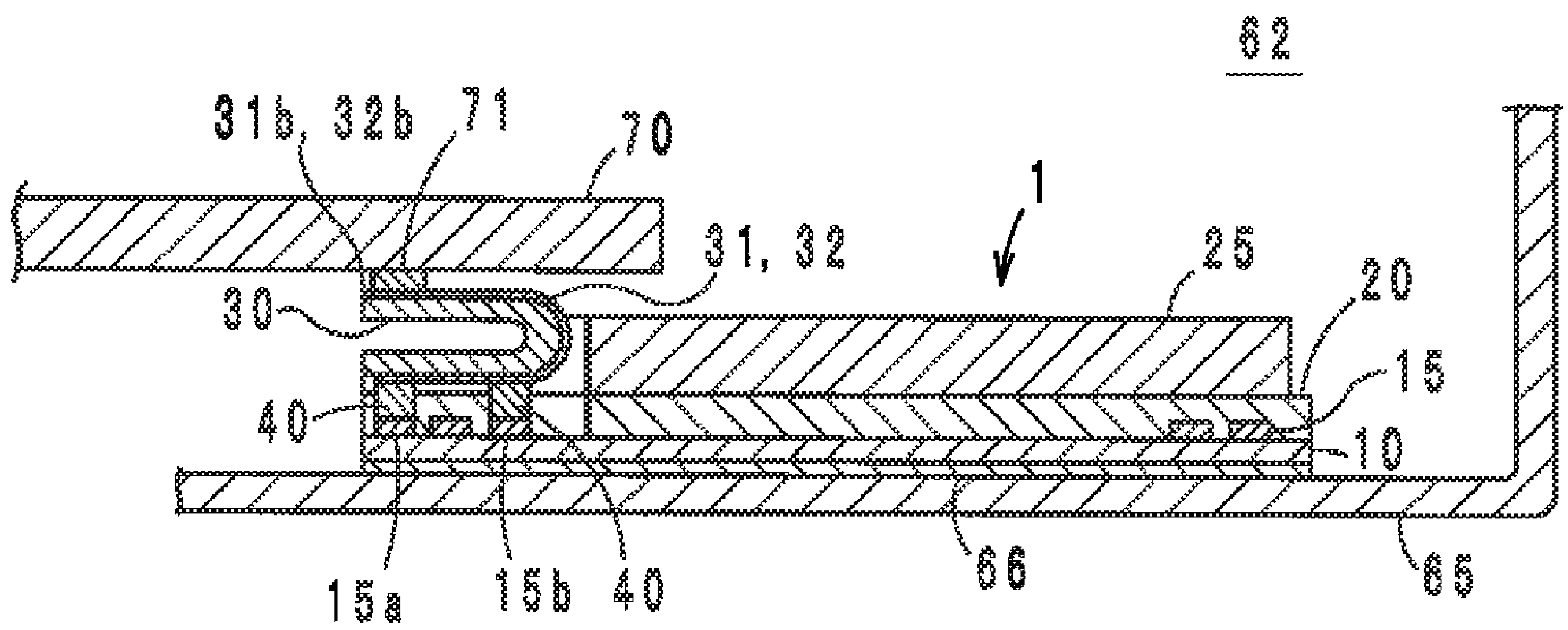
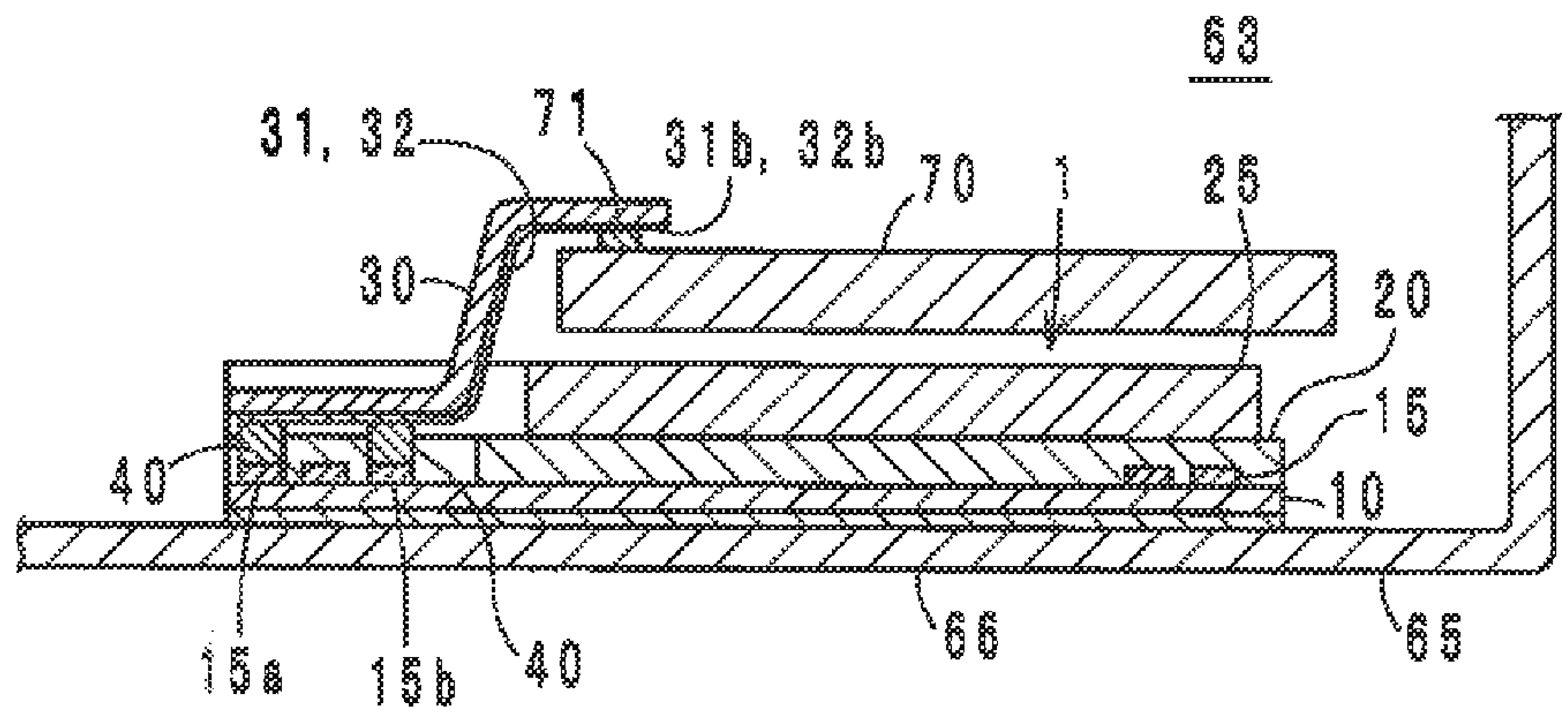


FIG. 10



62
31b, 32b
71
70
1
31, 32
25
20
30
15
40
10
15a
15b
40
66
65

FIG. 11



63
31, 32
71
31b, 32b
70
1
25
30
20
15
40
10
15a
15b
40
66
65

FIG. 12

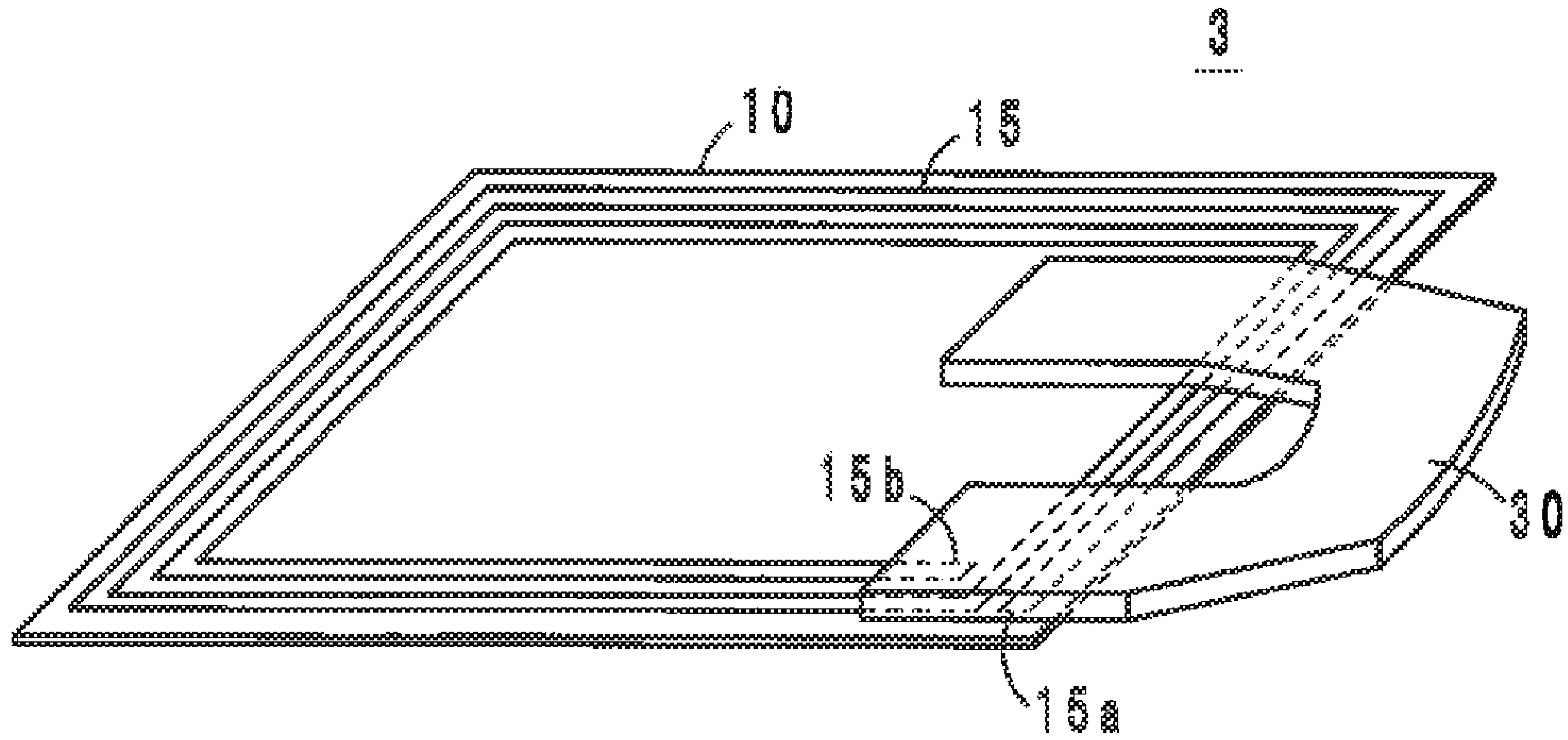


FIG. 13

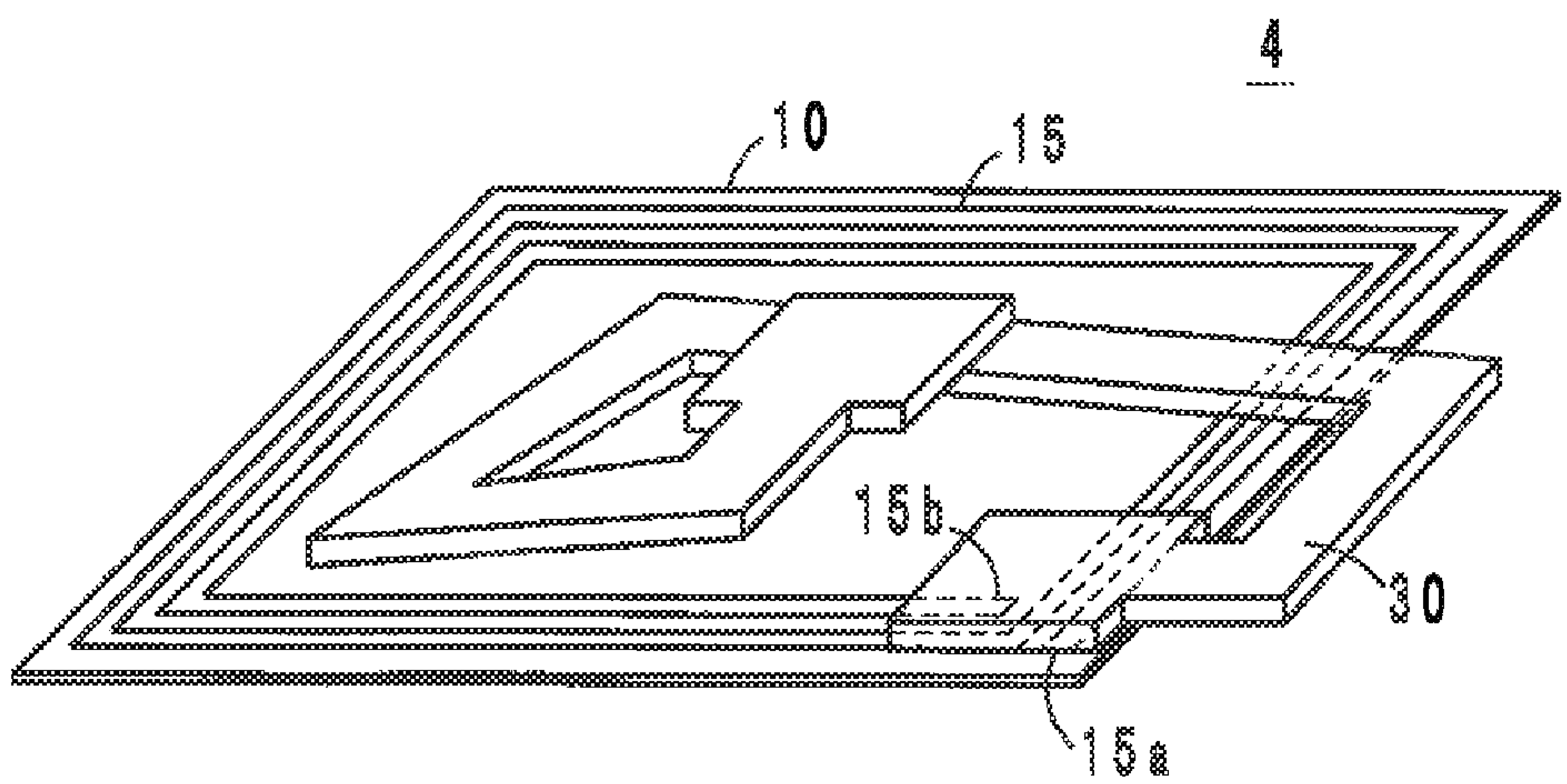


FIG. 14A

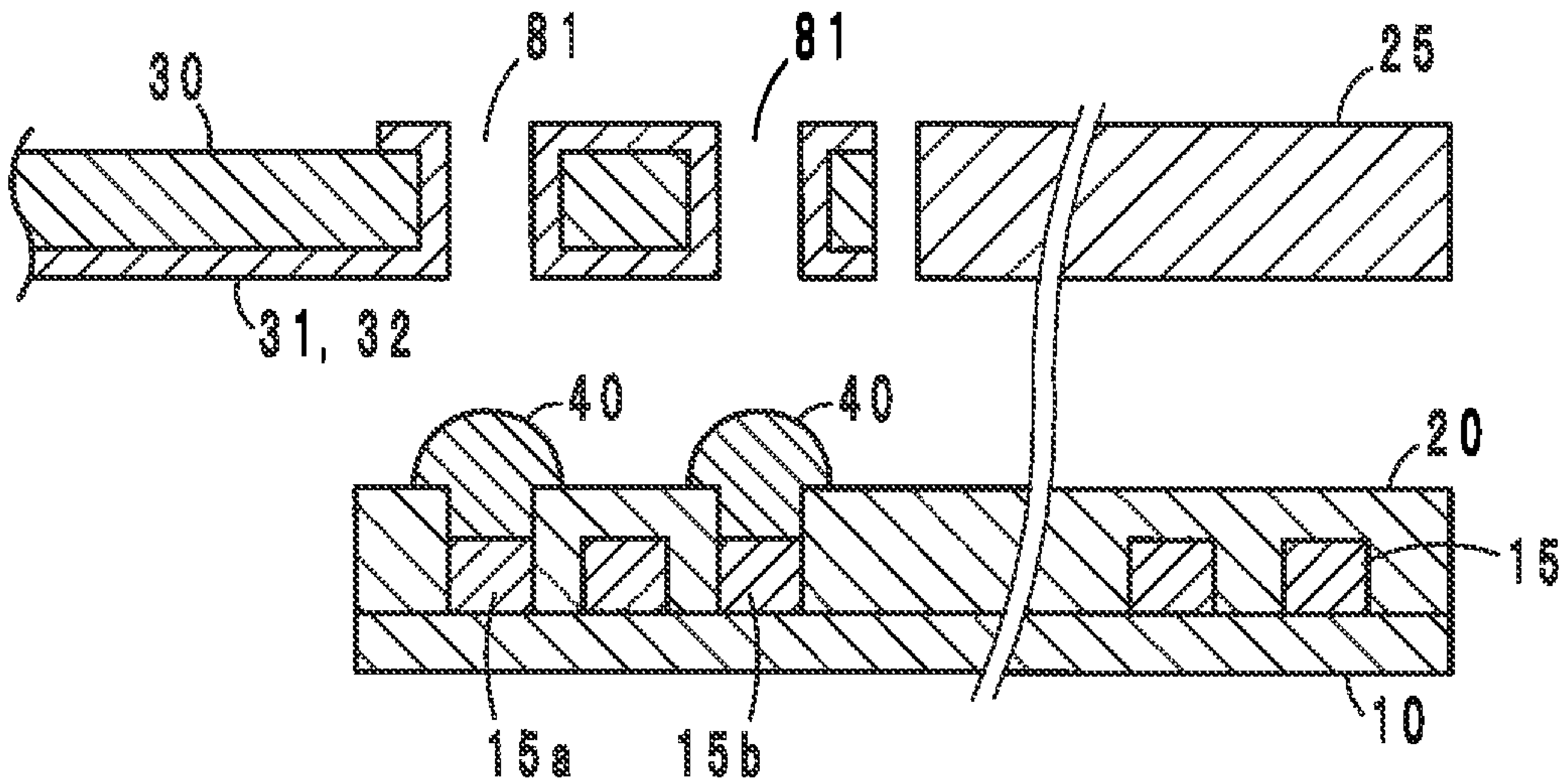


FIG. 14B

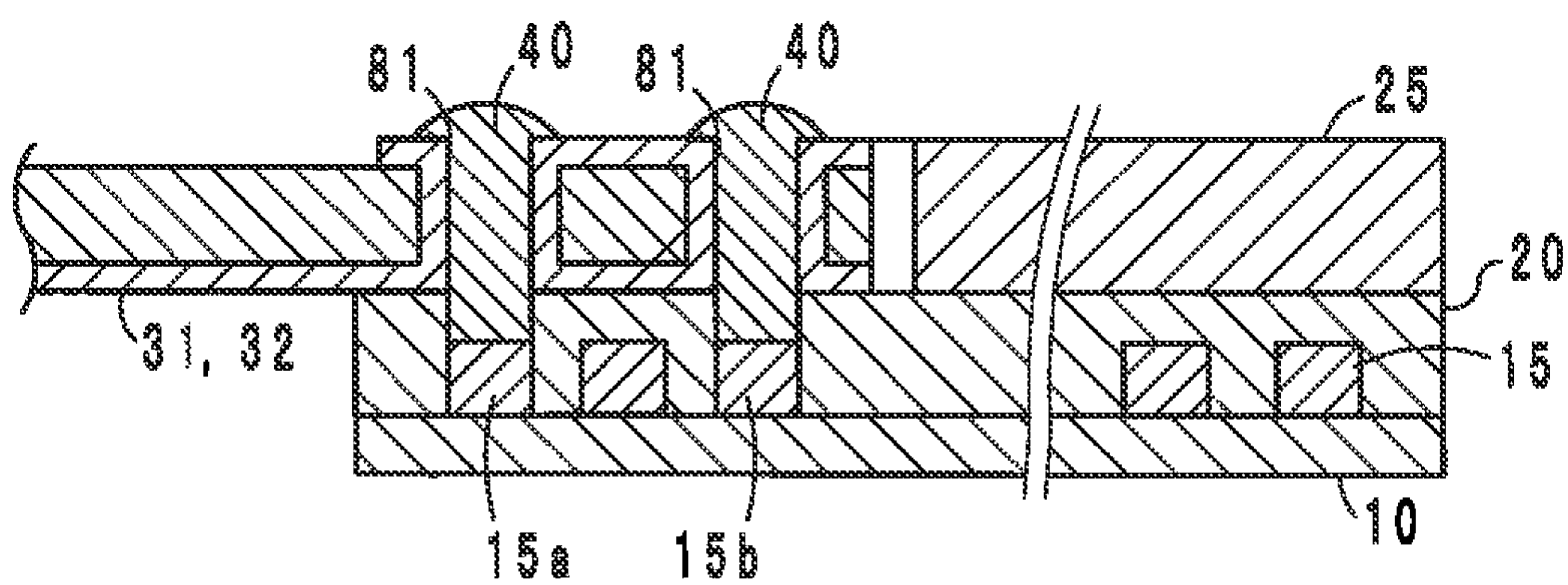


FIG. 15A

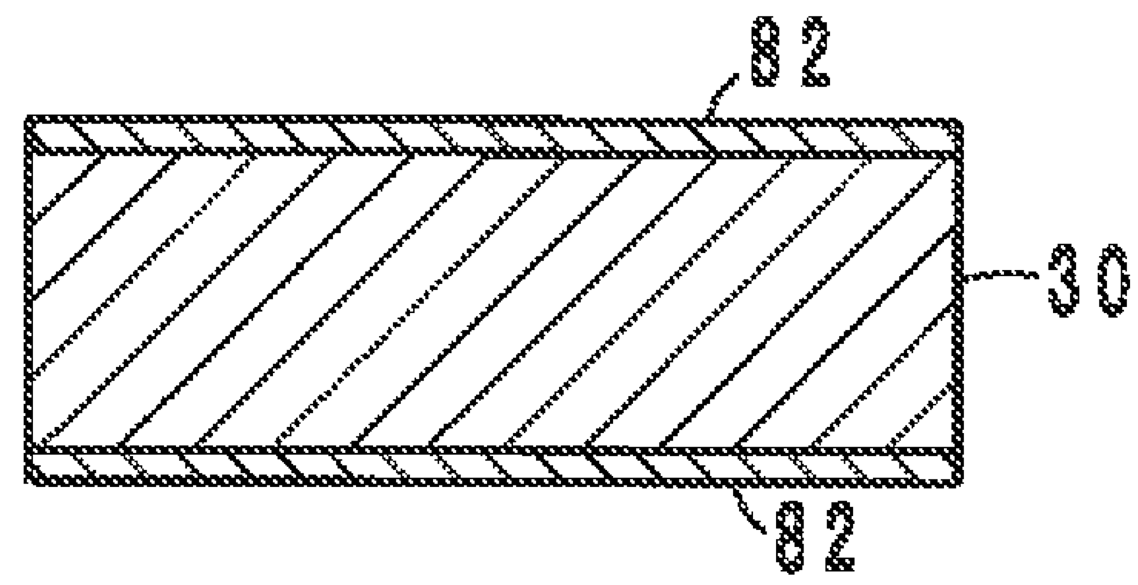


FIG. 15B

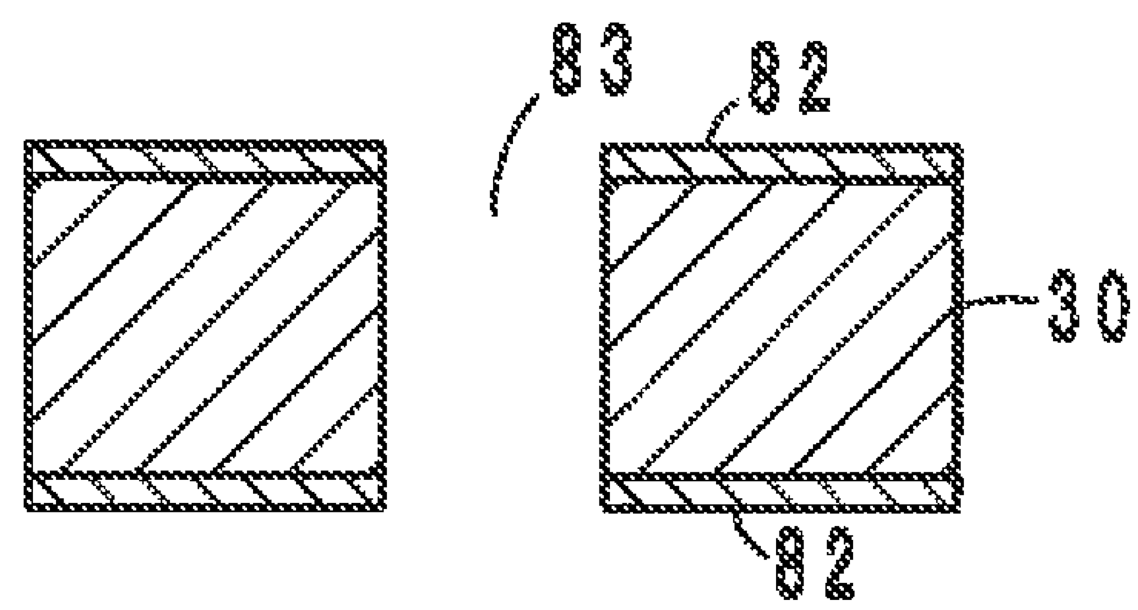


FIG. 15C

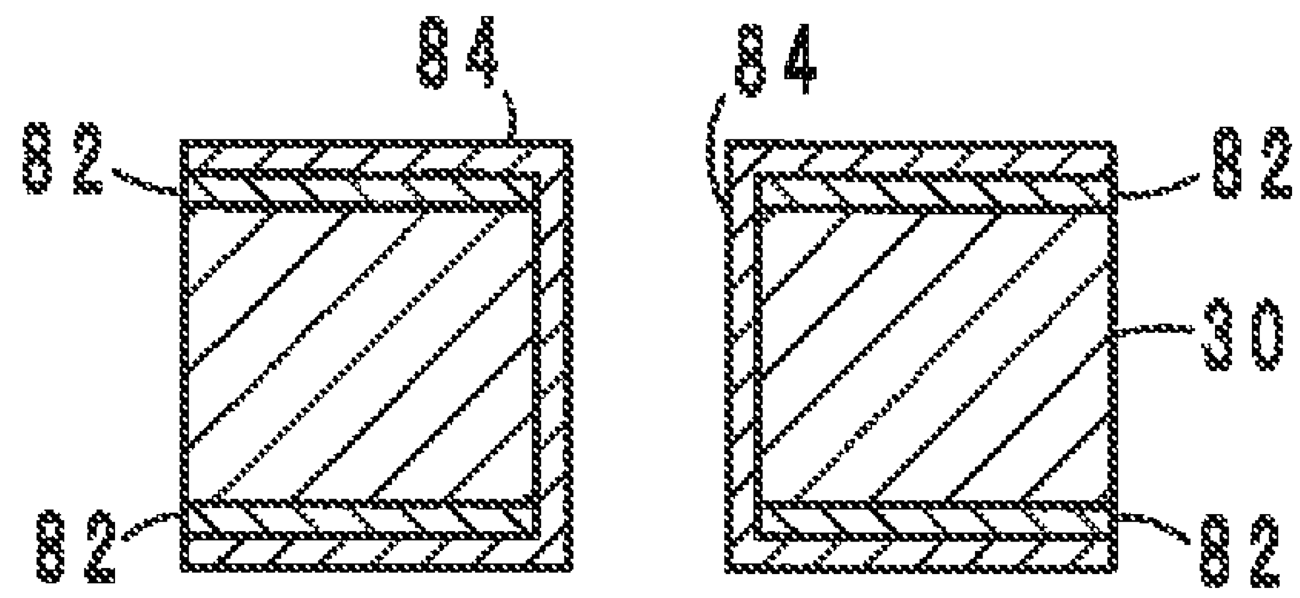


FIG. 15D

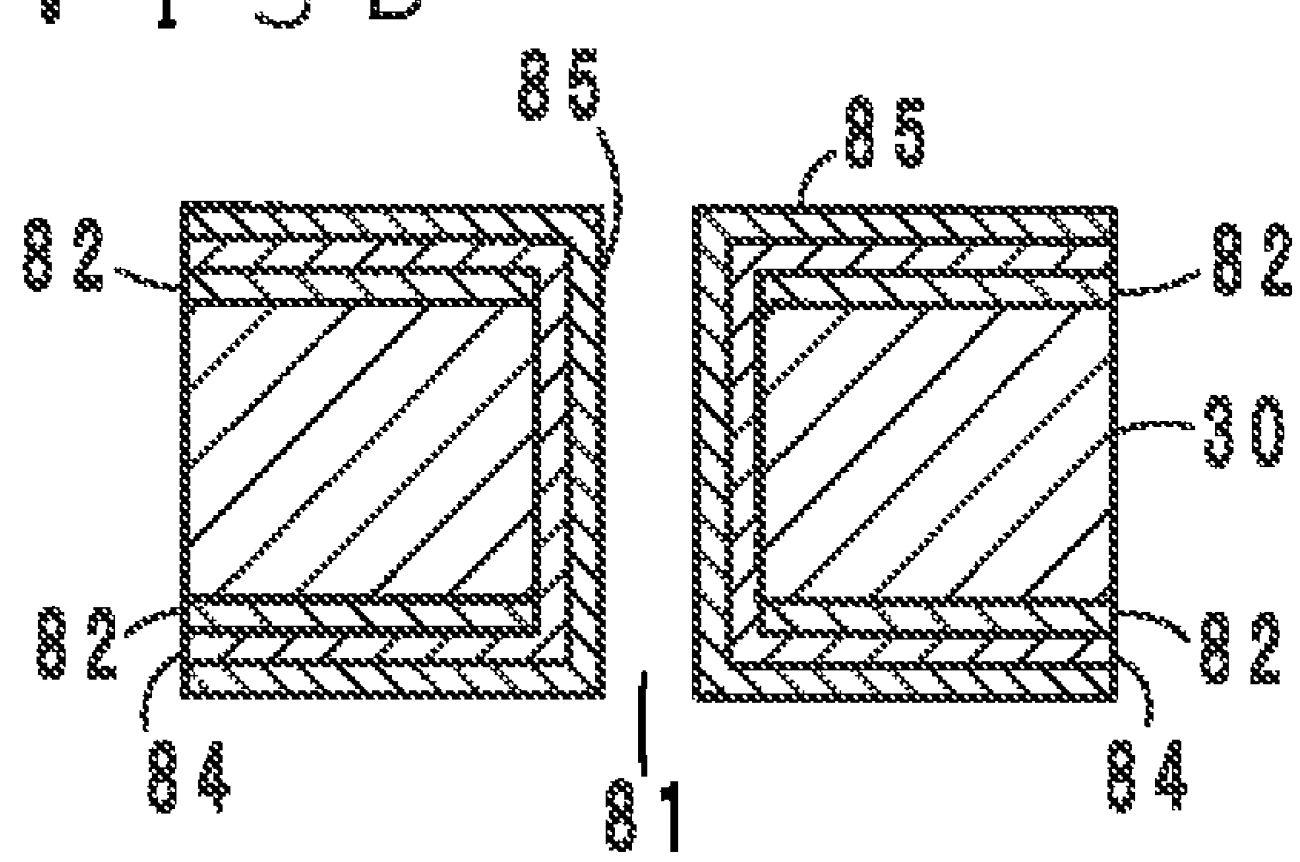


FIG. 16

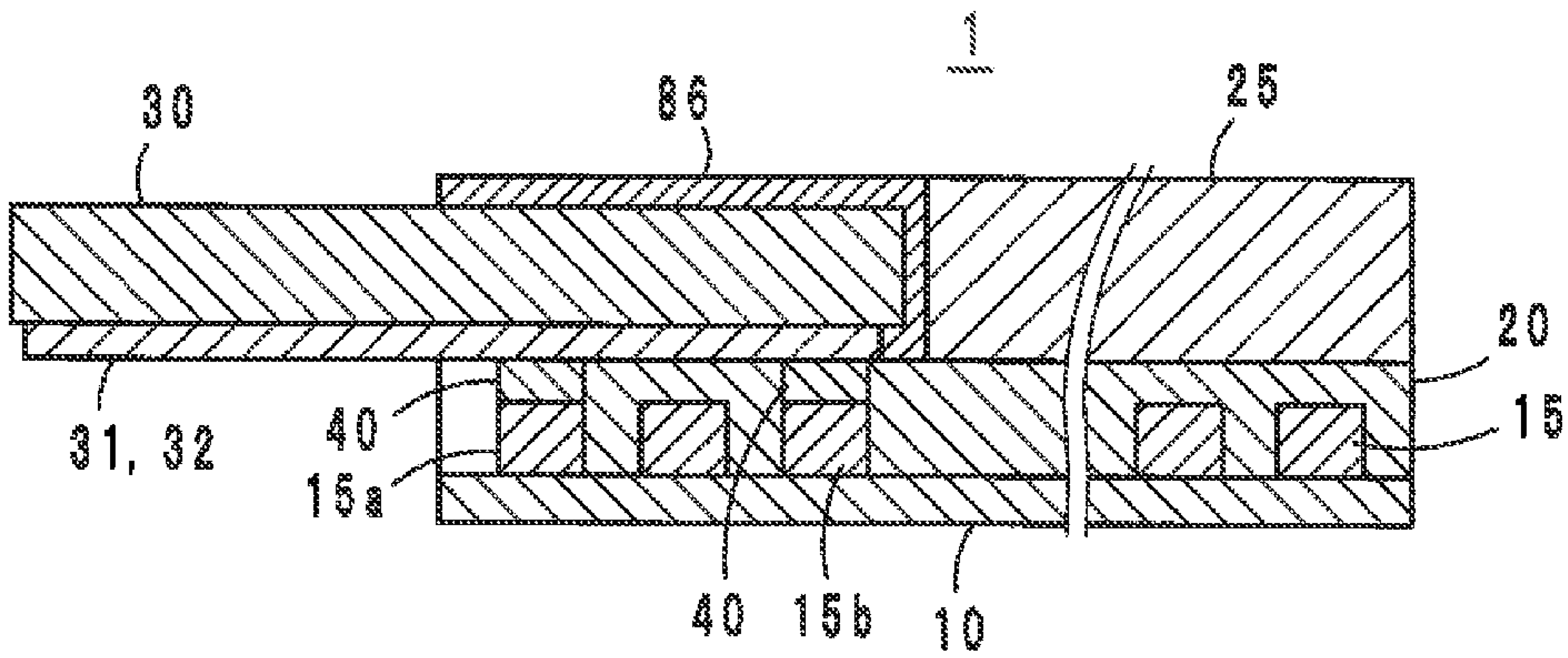

1
30
86
25
20
15
31, 32
40
15a
40
15b
10

FIG. 17

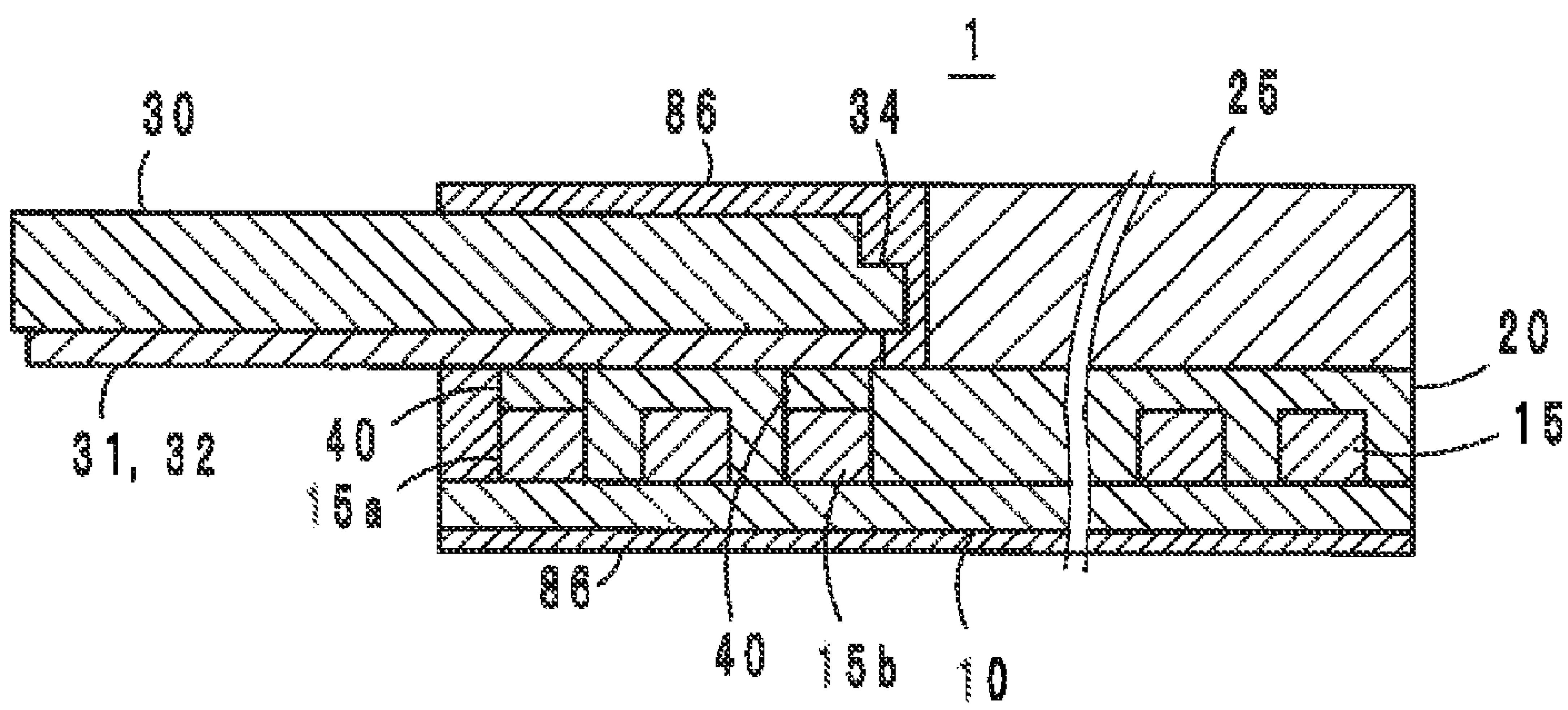

1
30
86
34
25
20
15
31, 32
40
15a
86
40
15b
10

FIG. 18

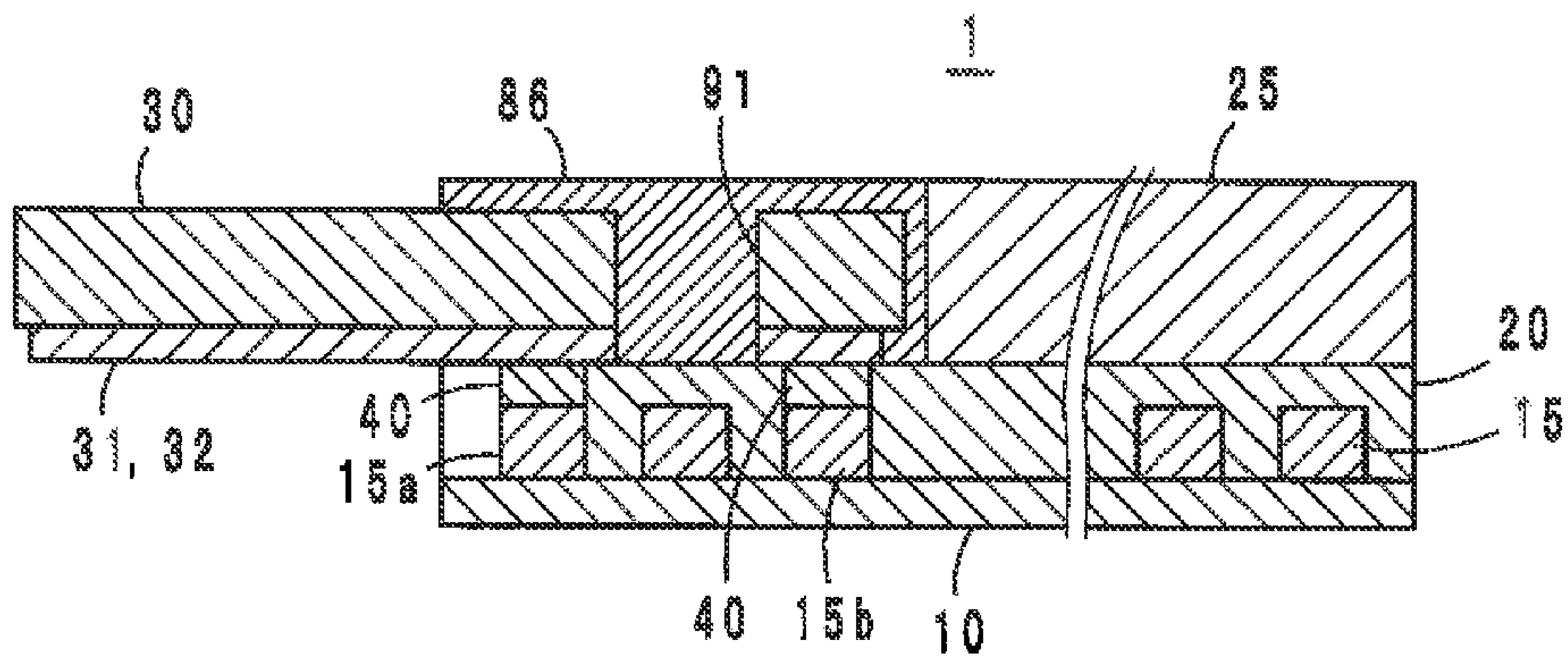

1
30
86
91
25
20
15
40
31, 32
15a
40
15b
10

FIG. 19

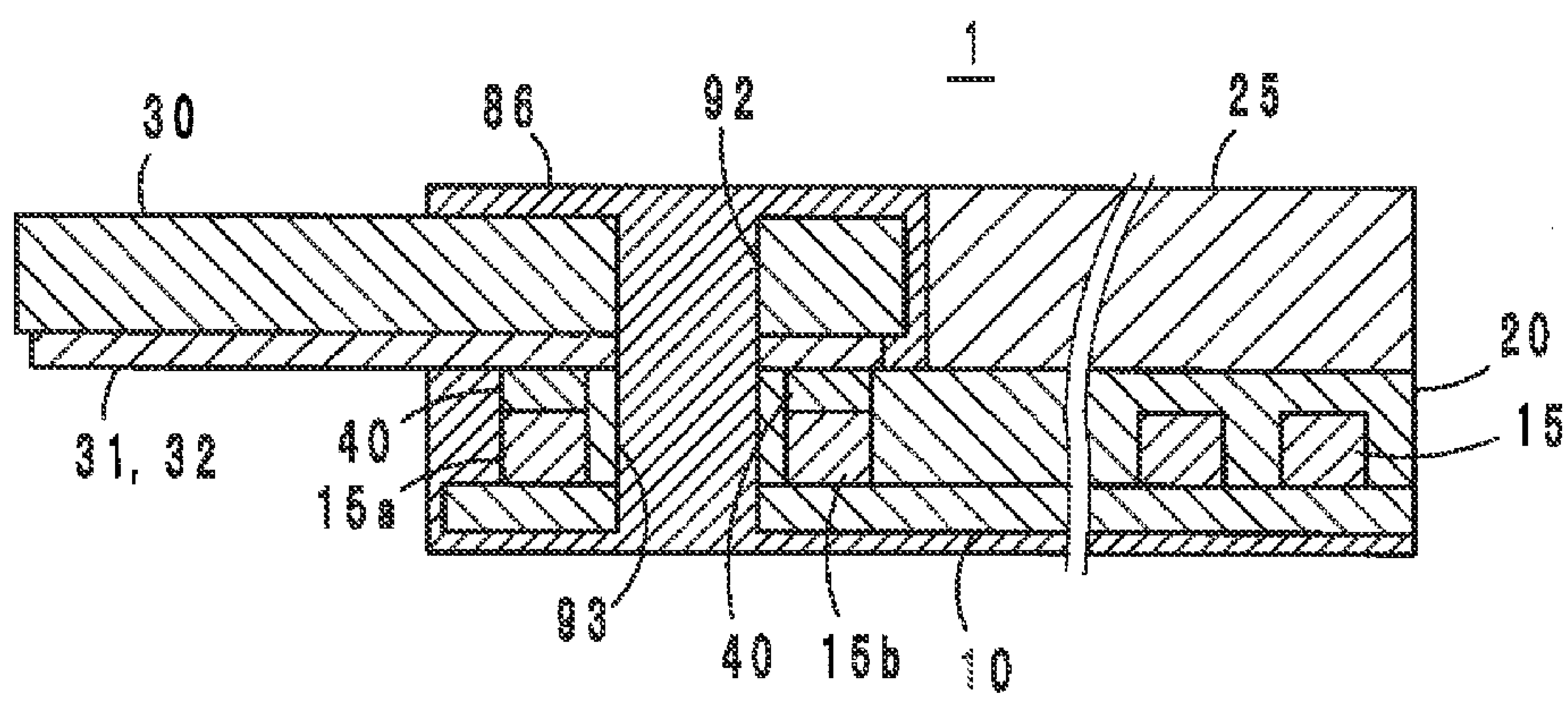
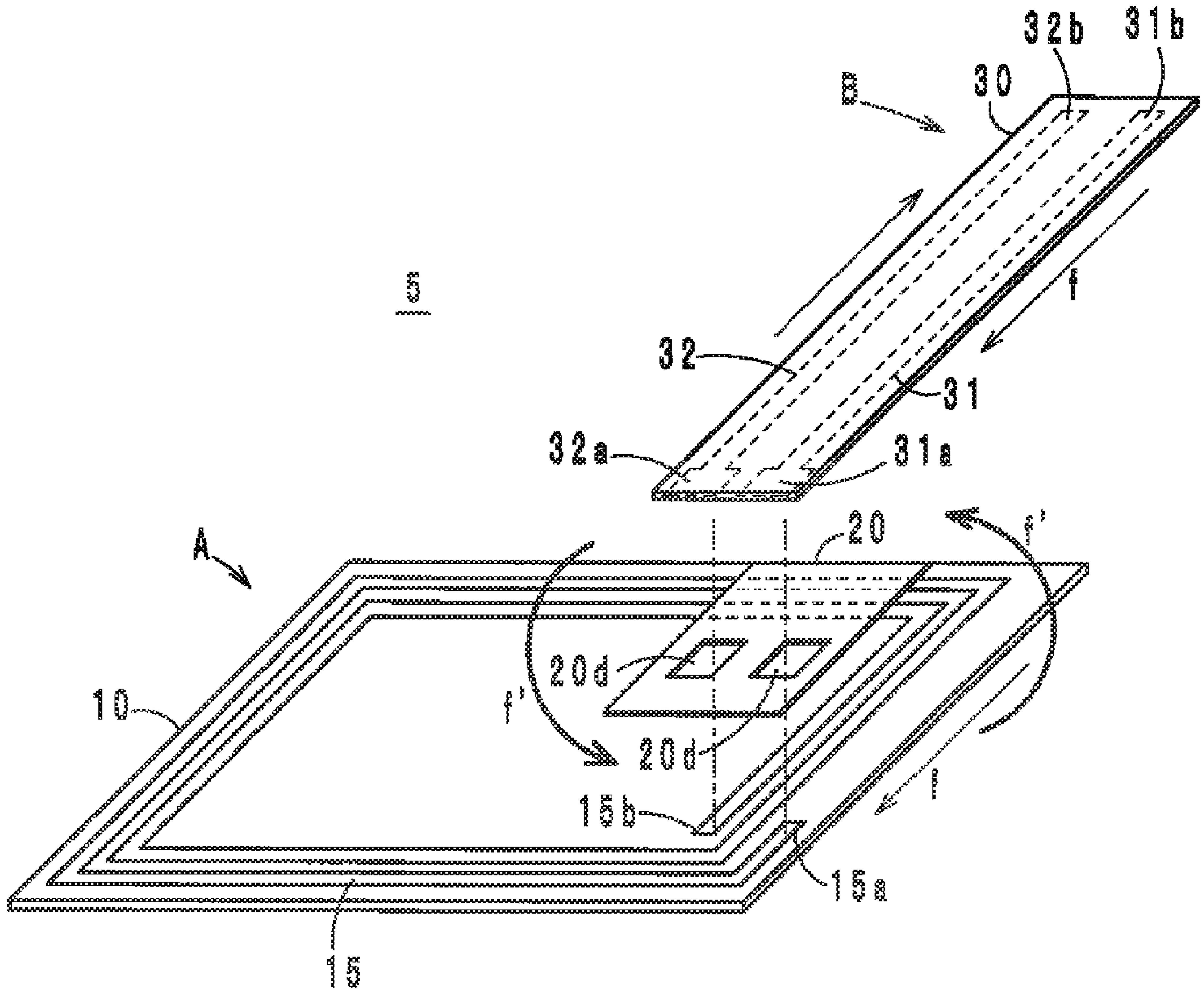
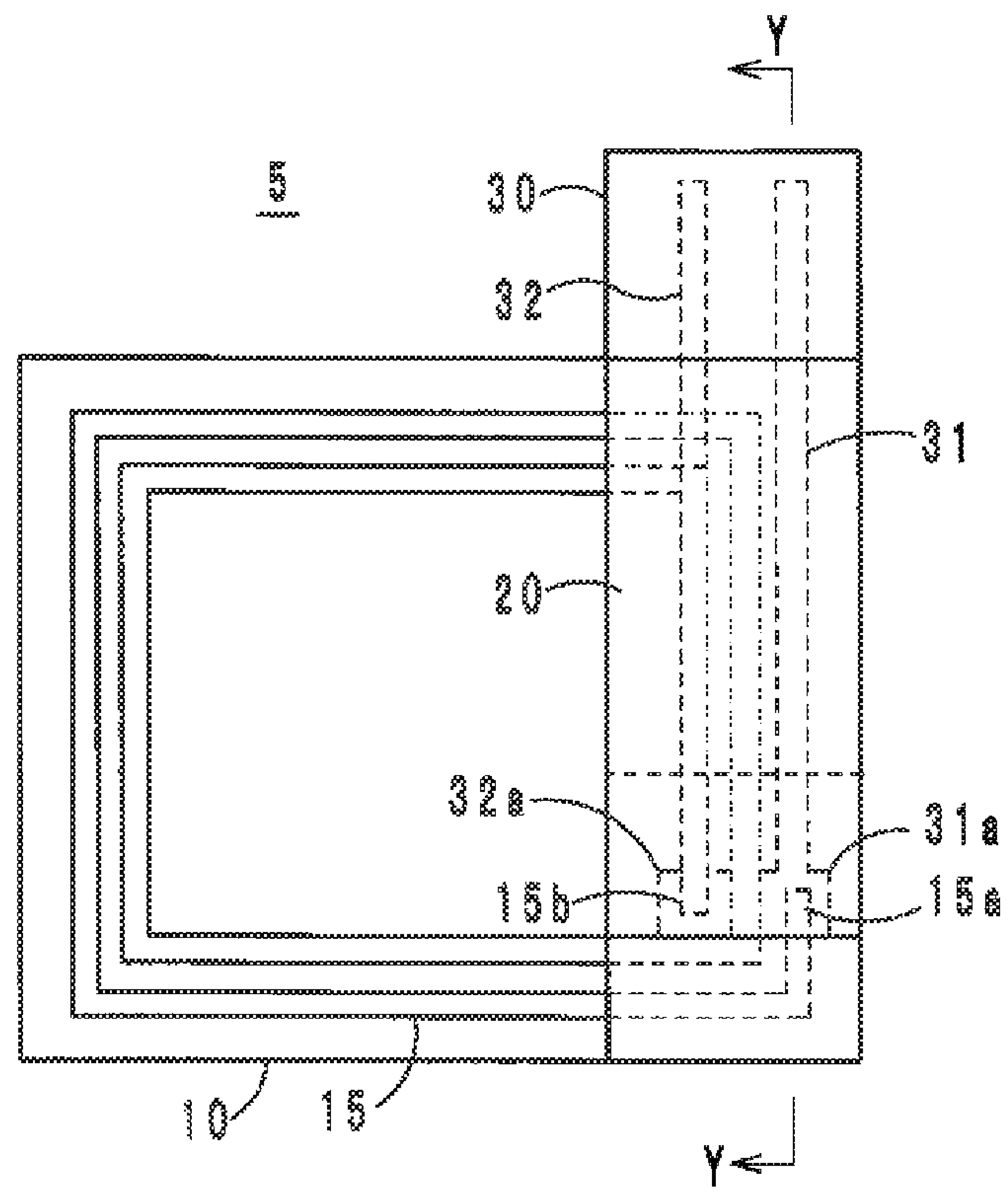

1
30
86
92
25
20
15
40
31, 32
15a
93
40
15b
10

FIG. 20



F I G. 21


5
30
32
31
20
32a
31a
15b
15a
10
15
Y
Y

F I G. 22

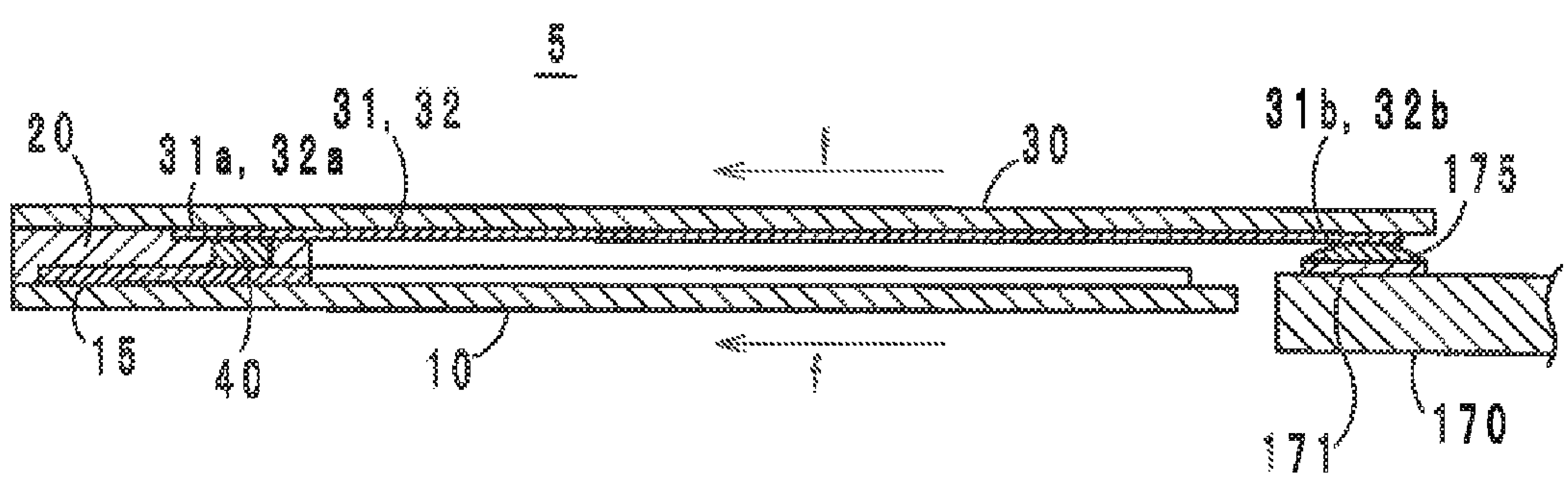

5
20
31a, 32a
31, 32
30
31b, 32b
175
15
40
10
171
170

FIG. 23

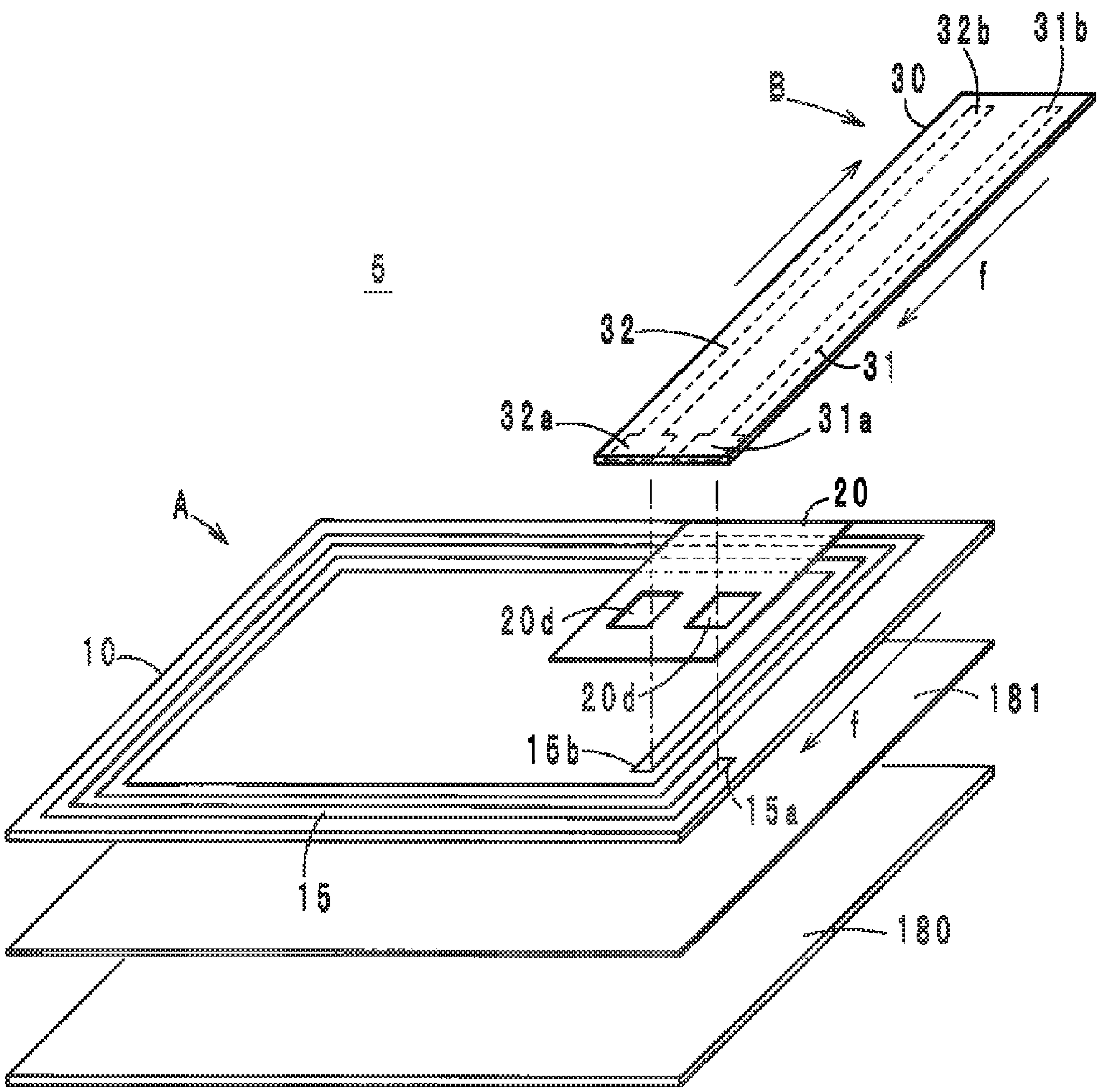


FIG. 24

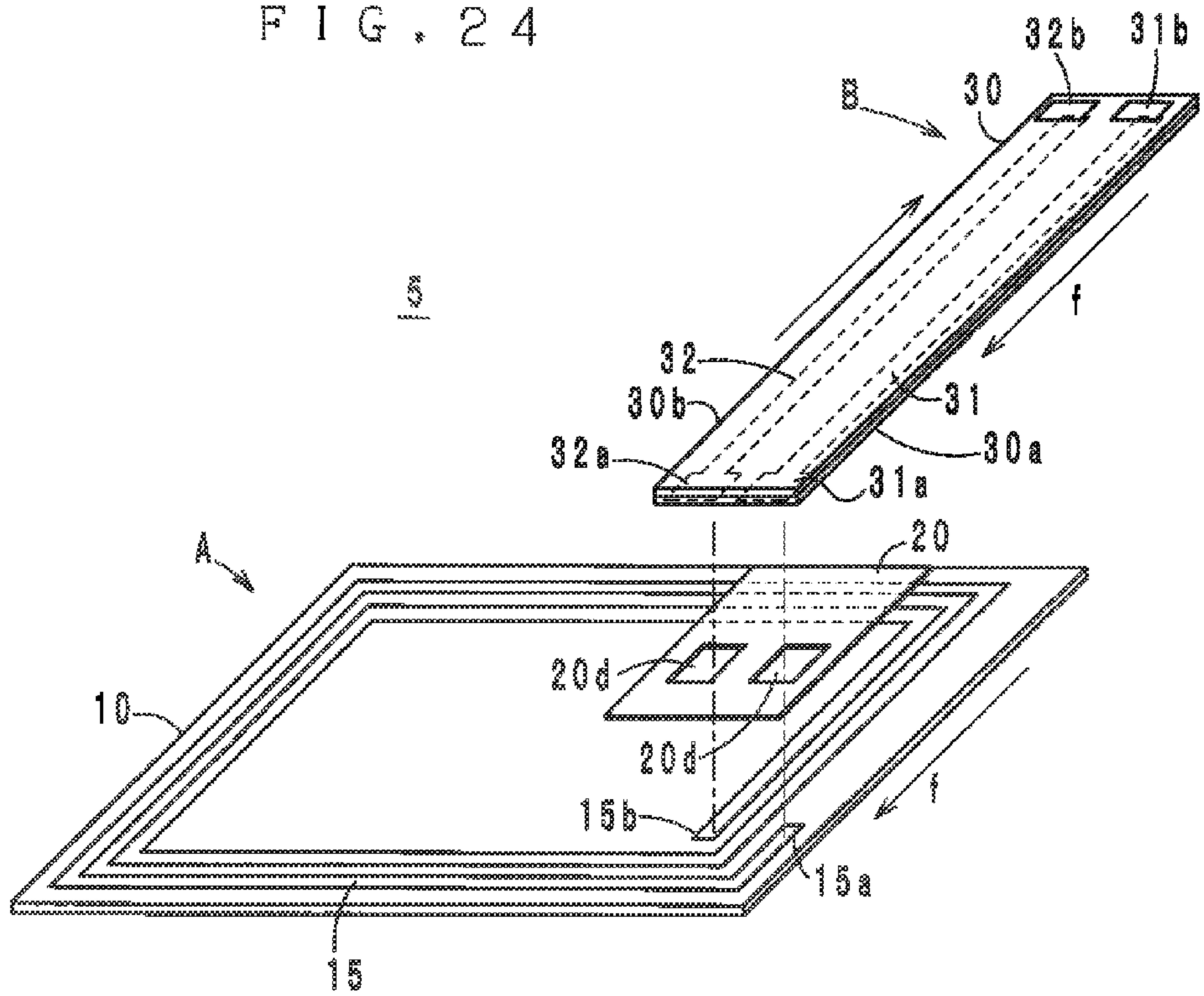


FIG. 25

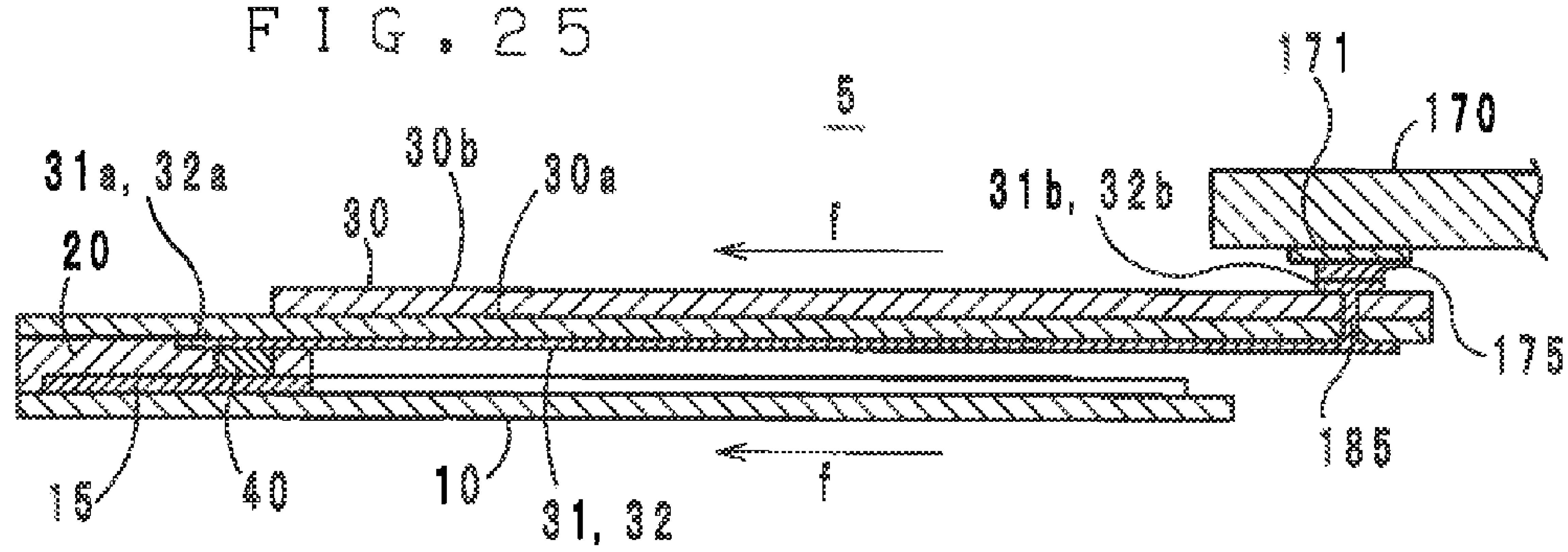


FIG. 26

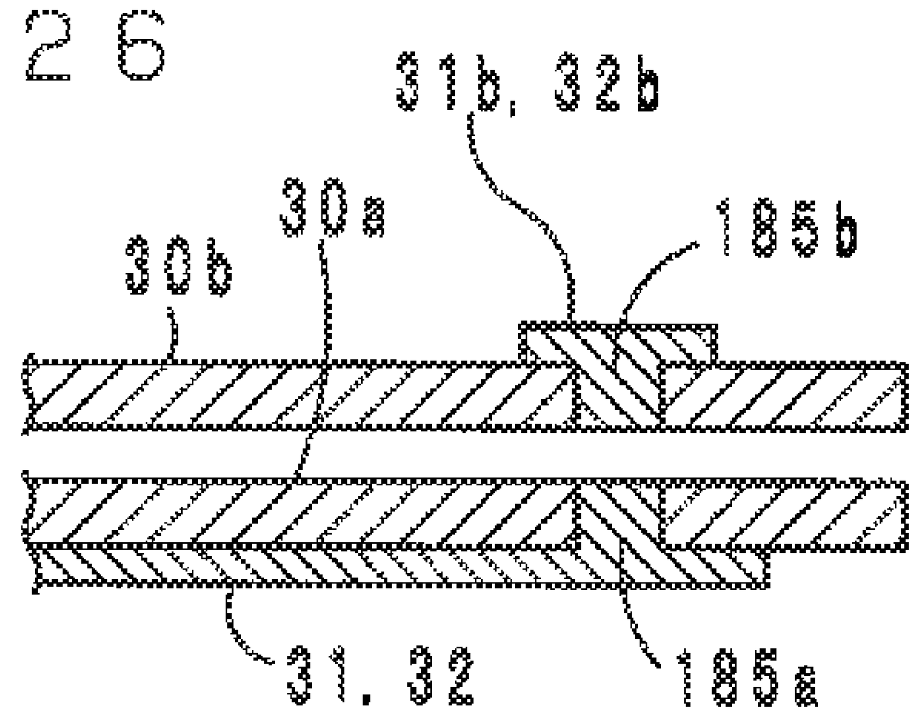


FIG. 27

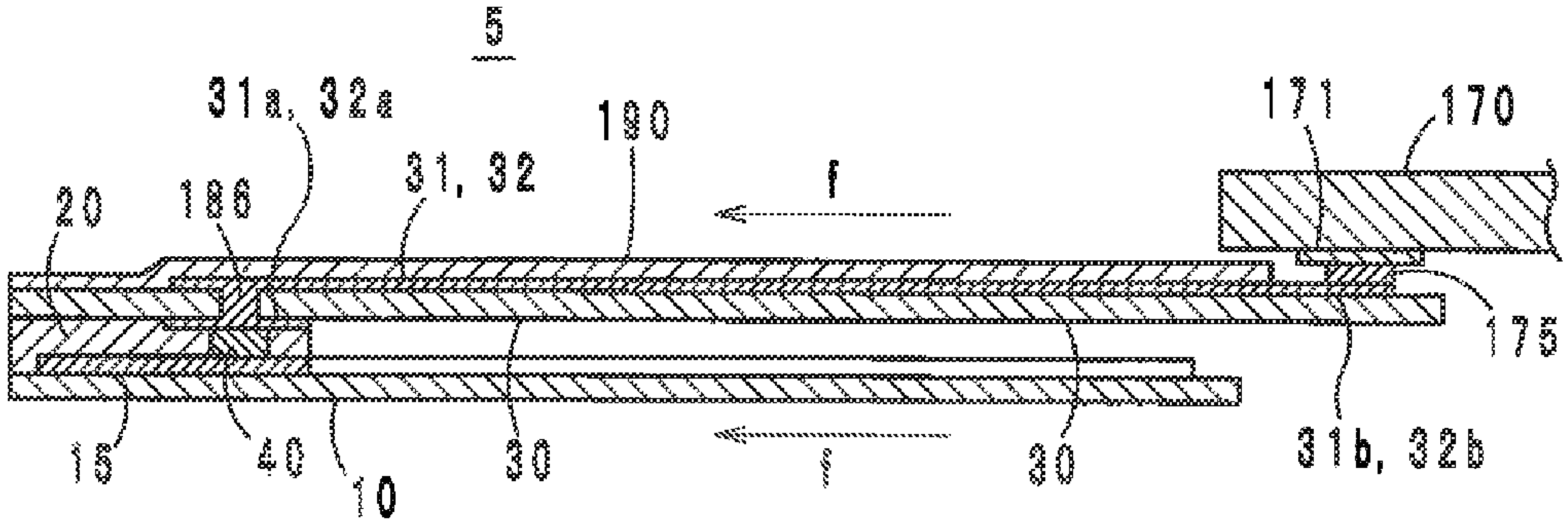

5
31a, 32a
190
171
170
31, 32
f
20
186
175
15
40
10
30
f
30
31b, 32b

FIG. 28

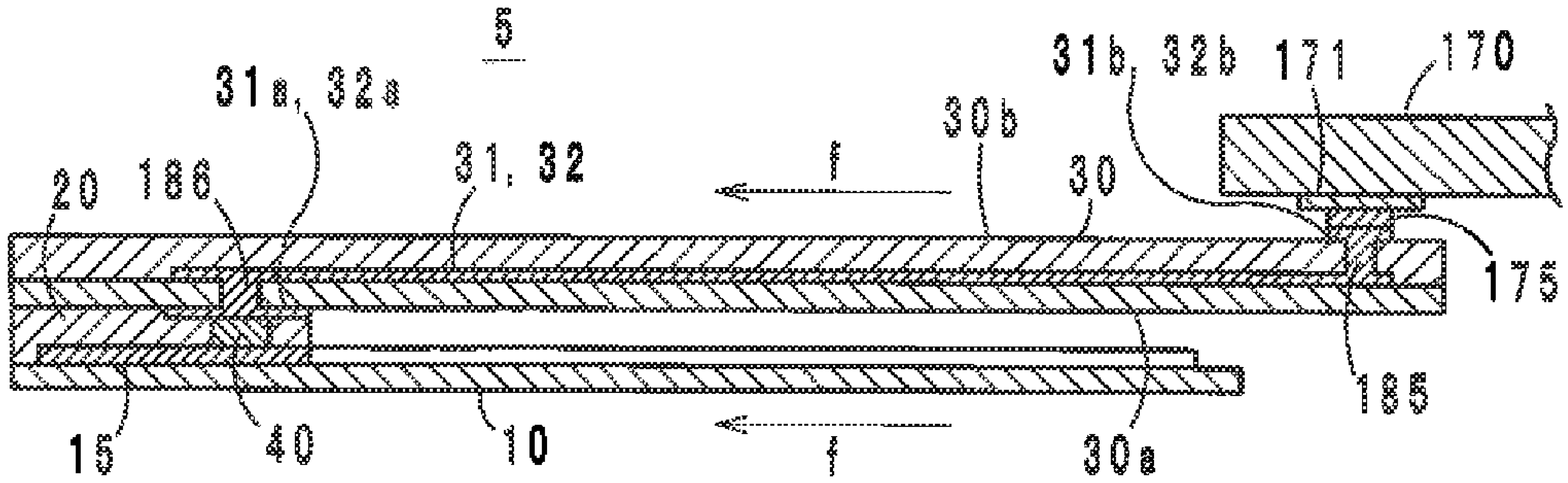

5
31a, 32a
31b, 32b
171
170
30b
20
186
31, 32
f
30
175
185
15
40
10
f
30a

FIG. 29

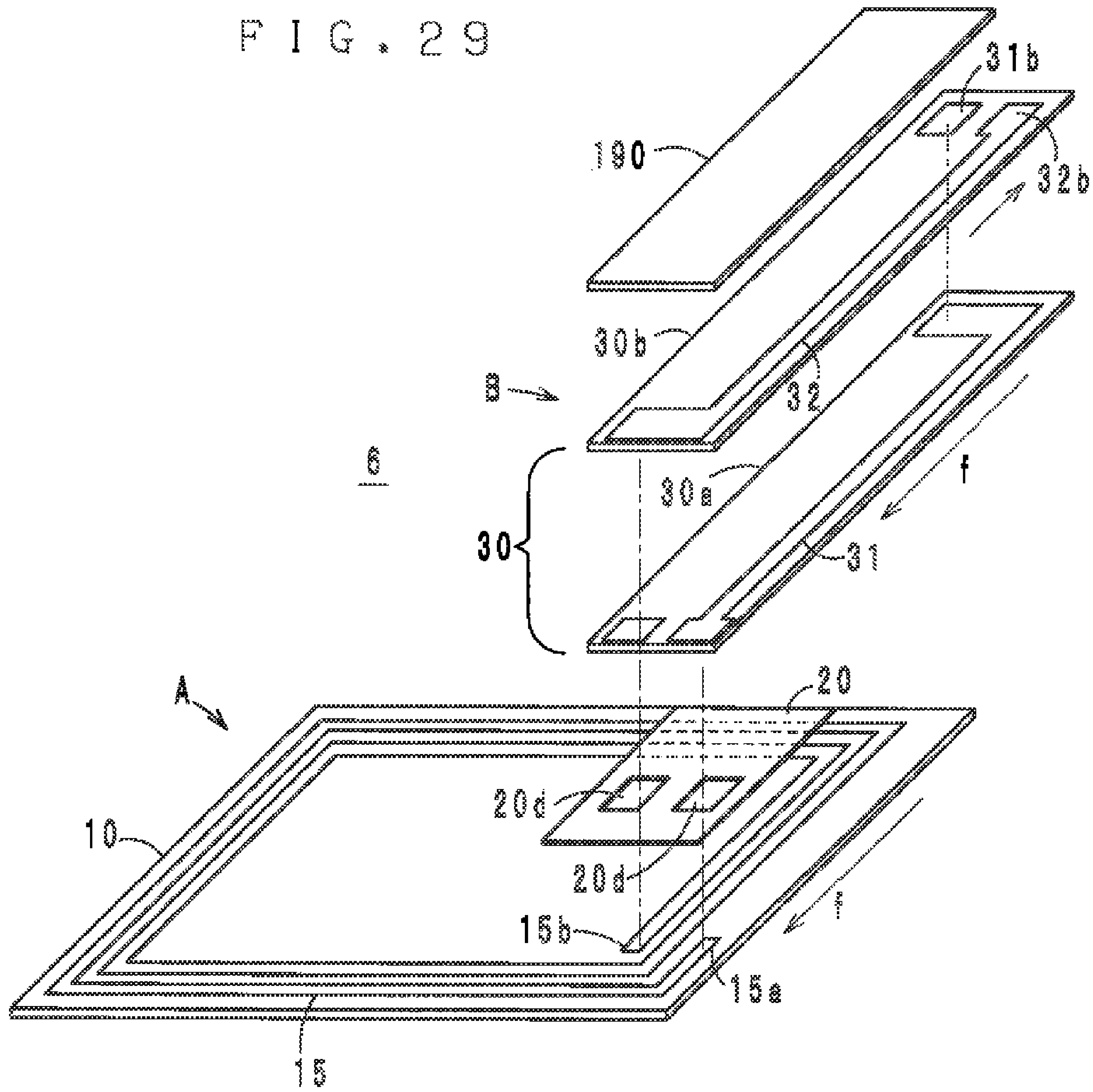

31b
190
32b
30b
B
32
6
30a
f
30
31
20
A
20d
10
20d
15b
f
15a
15

FIG. 30

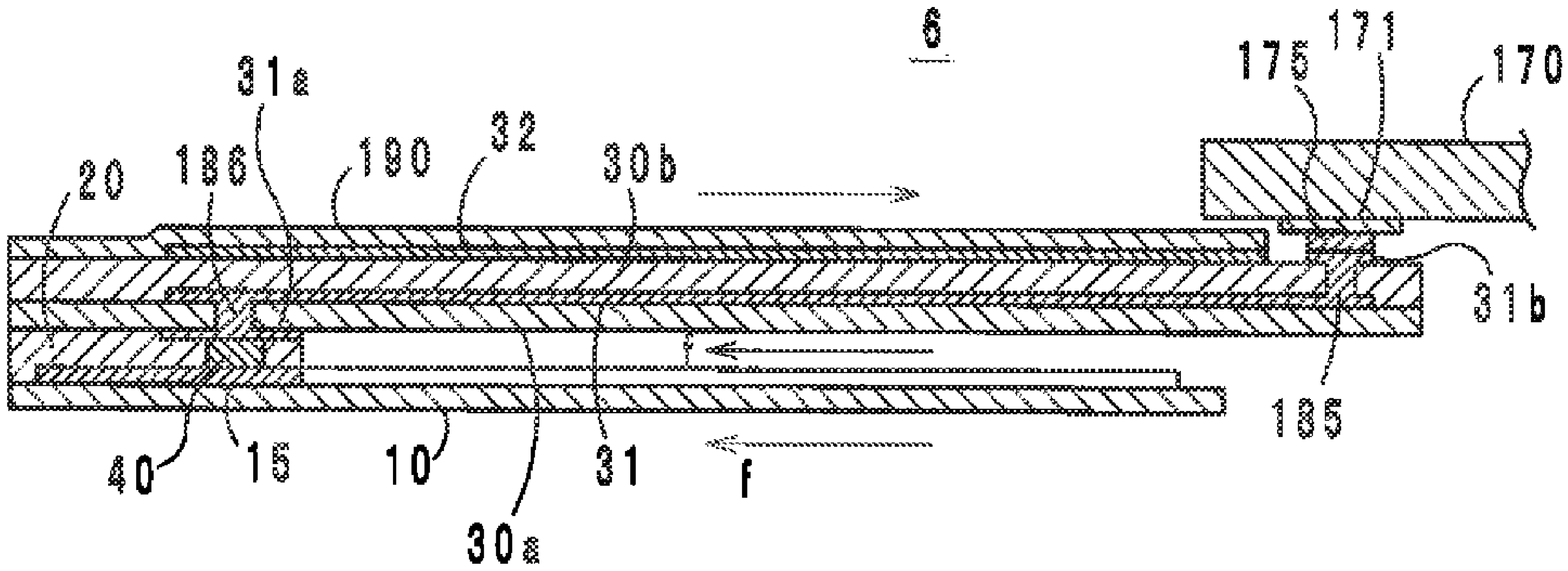

6
31a
175
171
170
20
186
190
32
30b
31b
185
40
15
10
31
f
30a

FIG. 31

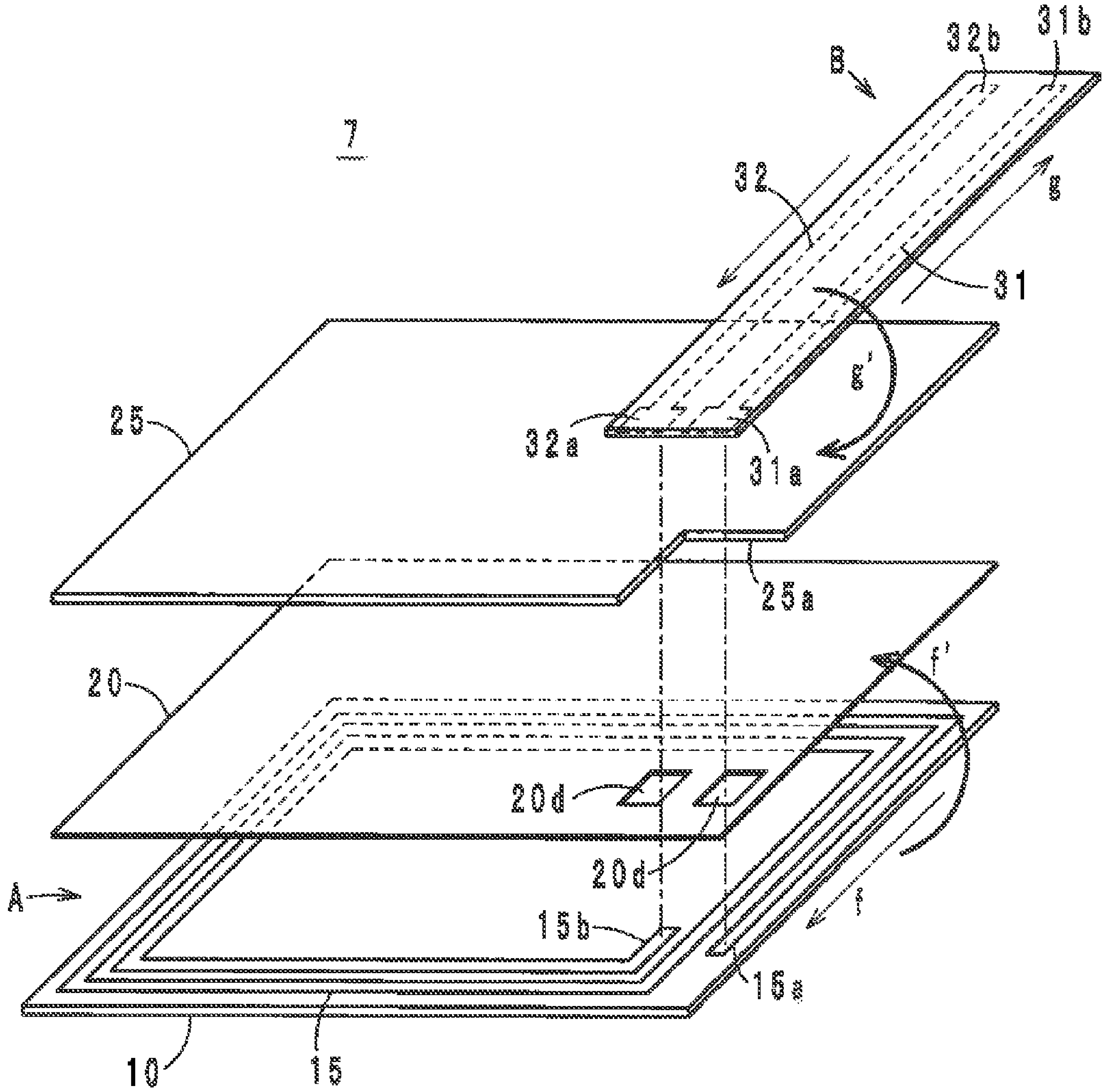


FIG. 32

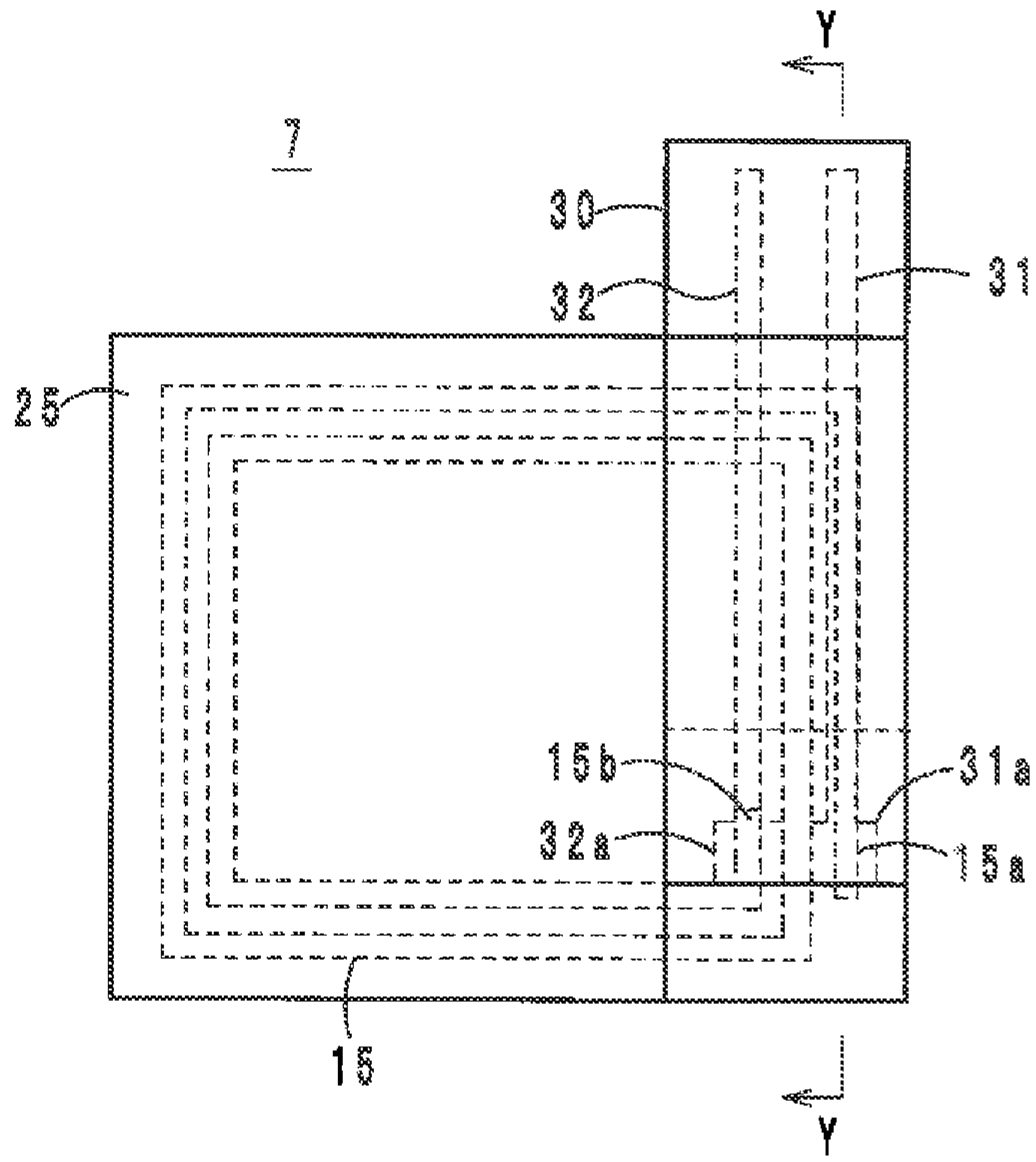

Y
7
30
32
31
25
15b
31a
32a
15a
15
Y

FIG. 33

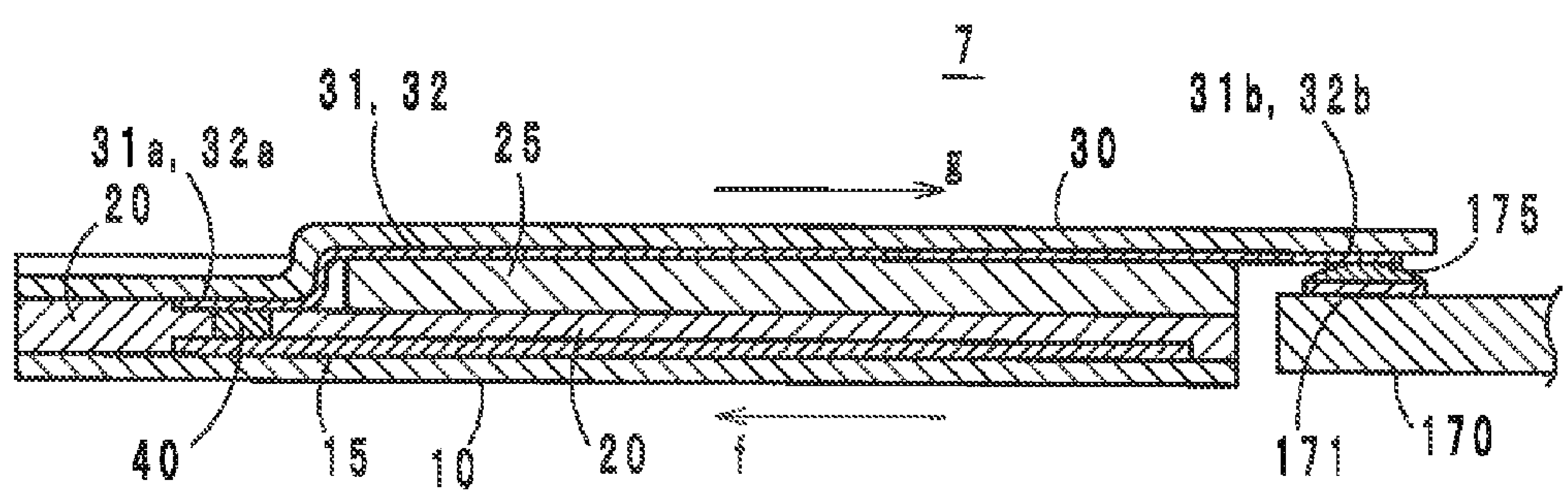

7
31, 32
31b, 32b
31a, 32a
25
g
30
20
175
40
15
10
20
f
171
170

FIG. 34

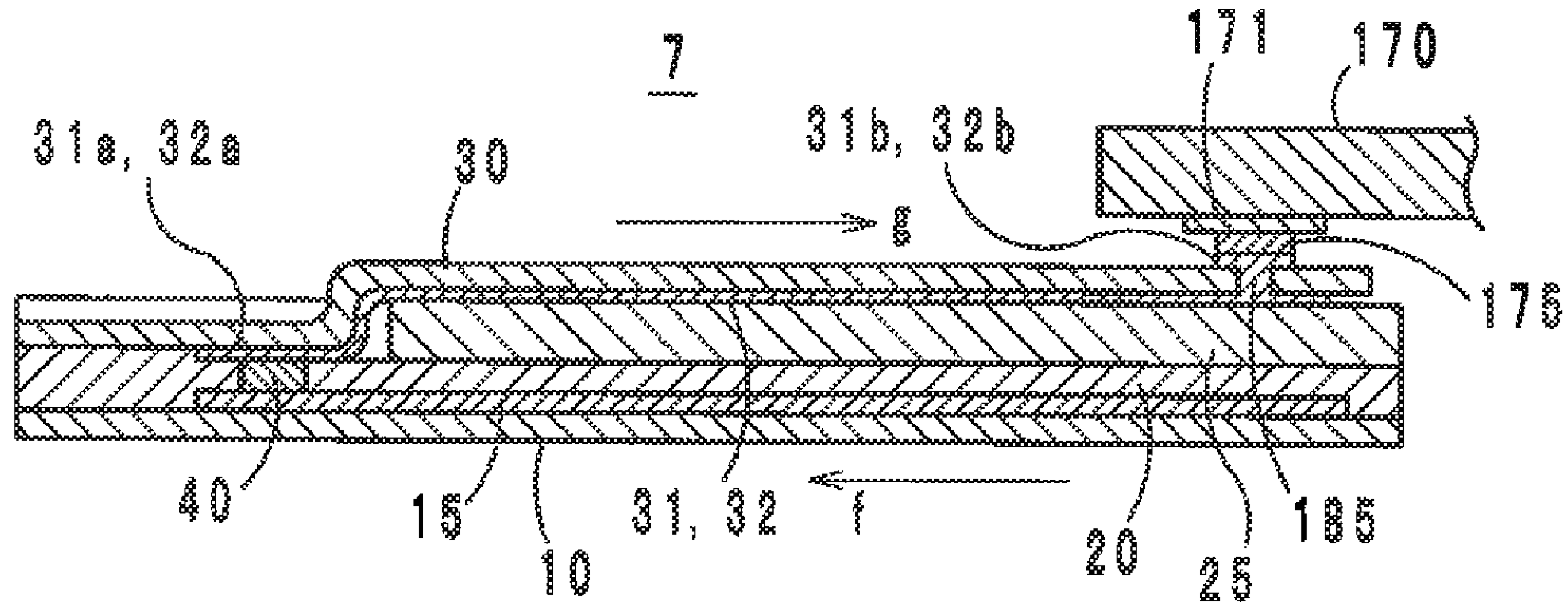


FIG. 35

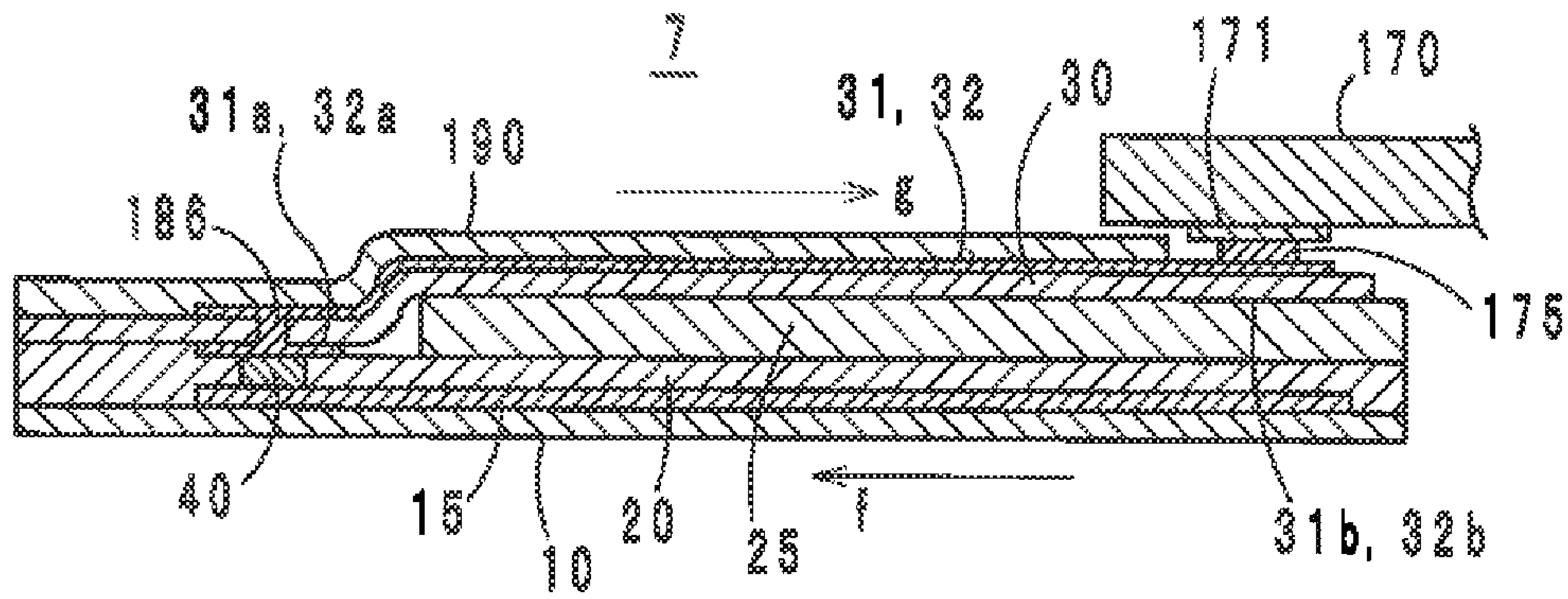


FIG. 36

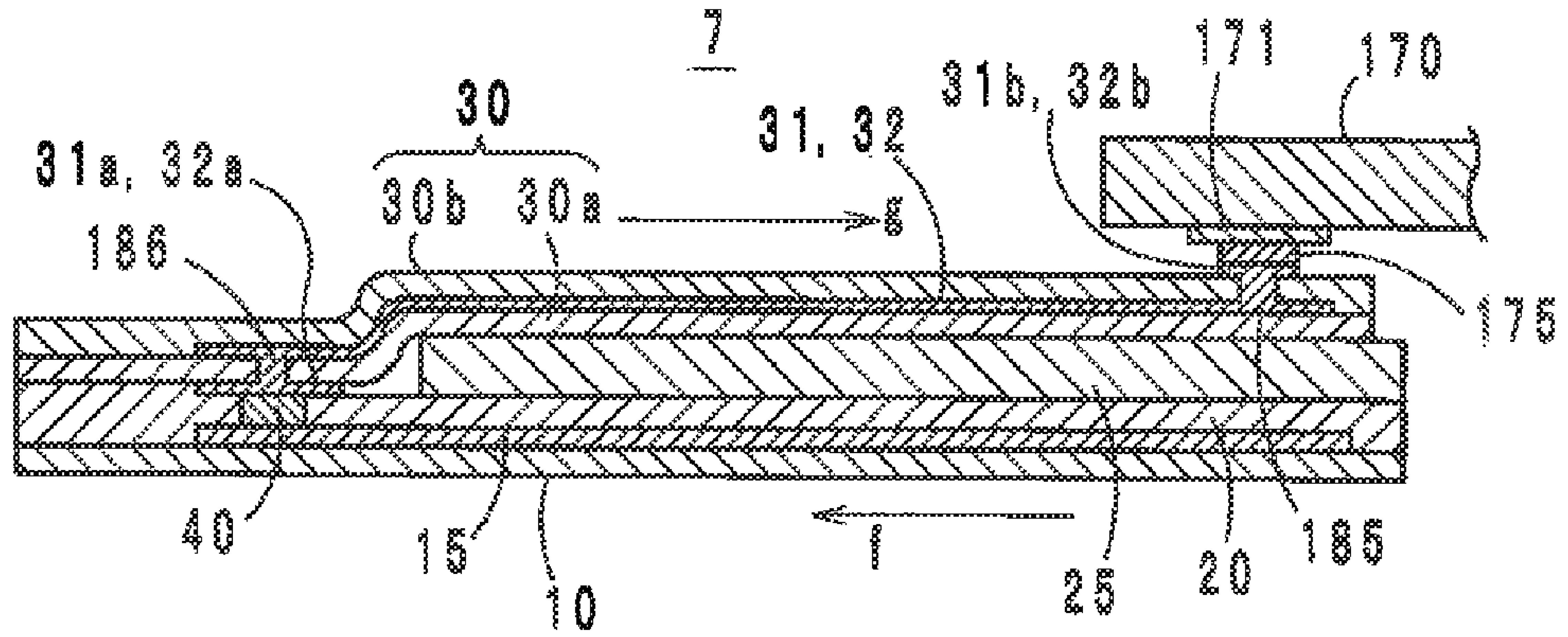


FIG. 37

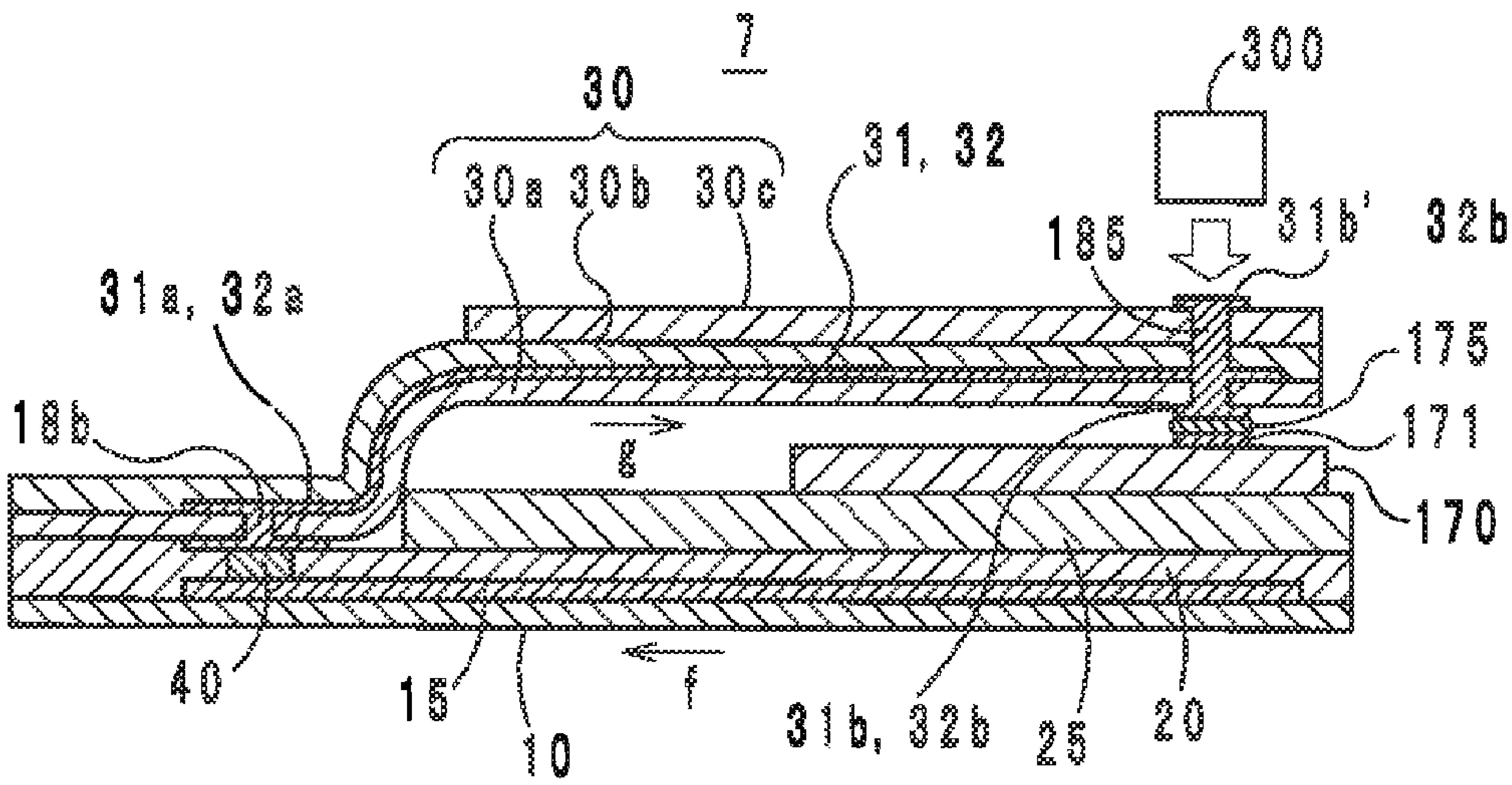

7
30
30a 30b 30c
31, 32
300
185
31b' 32b'
31a, 32a
175
18b
171
g
170
40
15
f
10
31b, 32b
25
20

FIG. 38

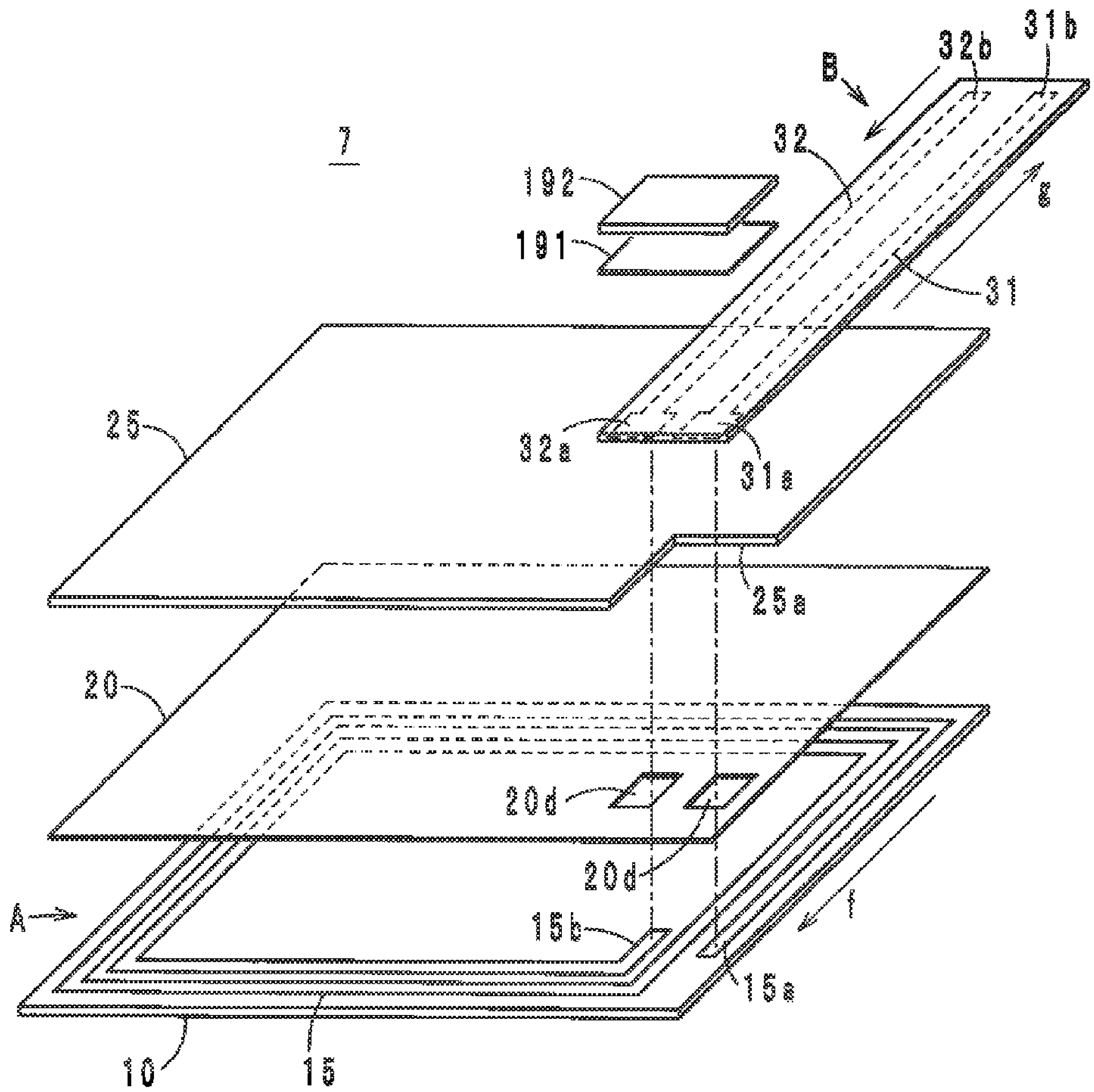

7
192
191
B
32b
31b
32
g
31
25
32a
31a
25a
20
20d
20d
A
15b
f
15a
10
15

FIG. 39

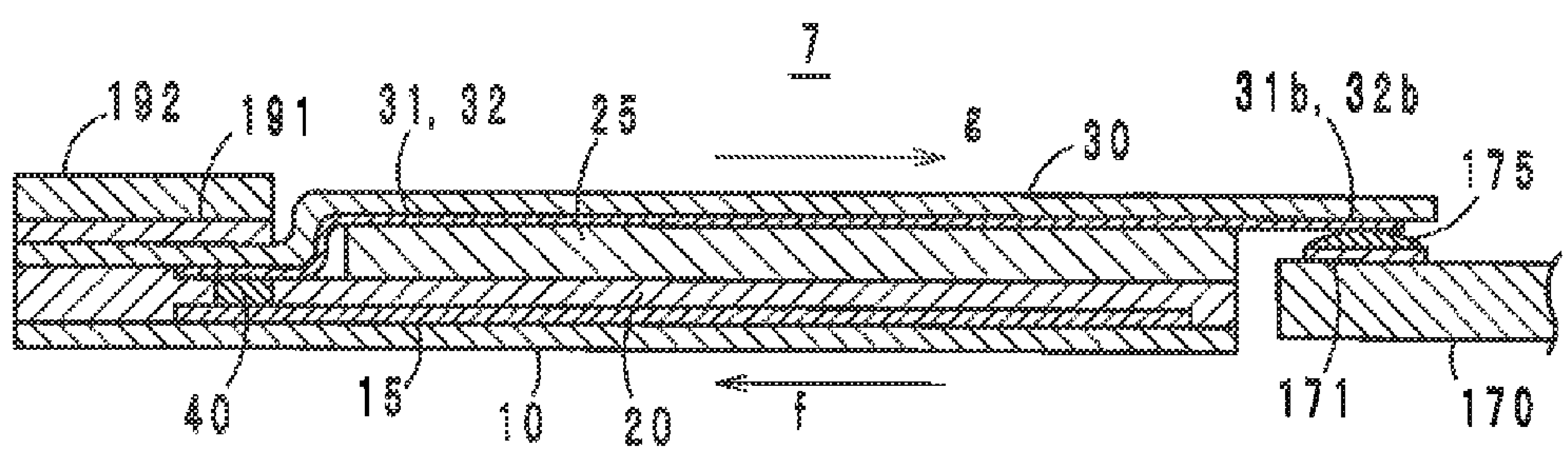

7
192
191
31, 32
25
g
30
31b, 32b
175
40
15
10
20
f
171
170

FIG. 40

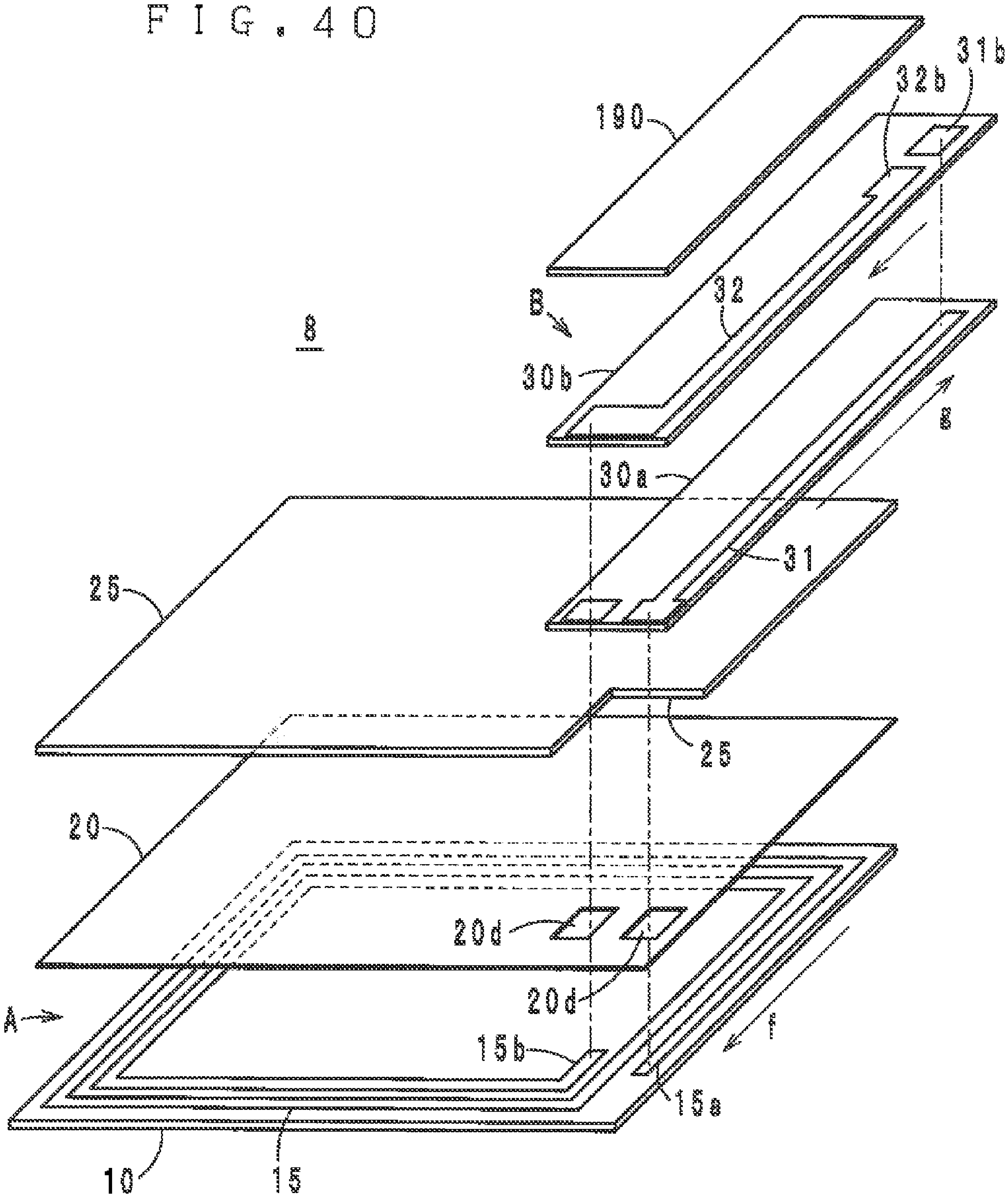

190
31b
32b
32
B
8
30b
g
30a
31
25
25
20
20d
20d
A
15b
f
15a
10
15

FIG. 41

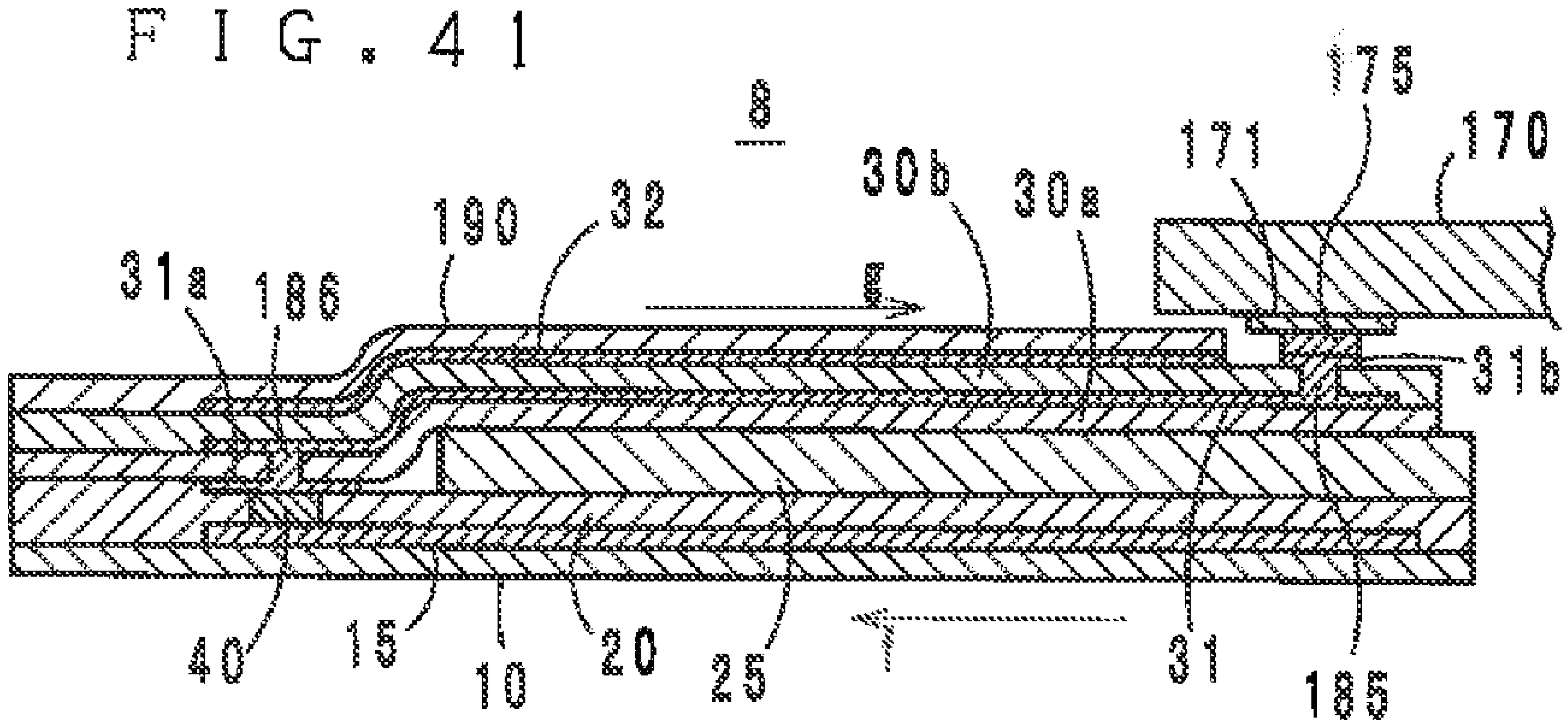

8
175
170
171
30b
30a
190
32
31a
186
g
31b
40
15
10
20
25
f
31
185

FIG. 42

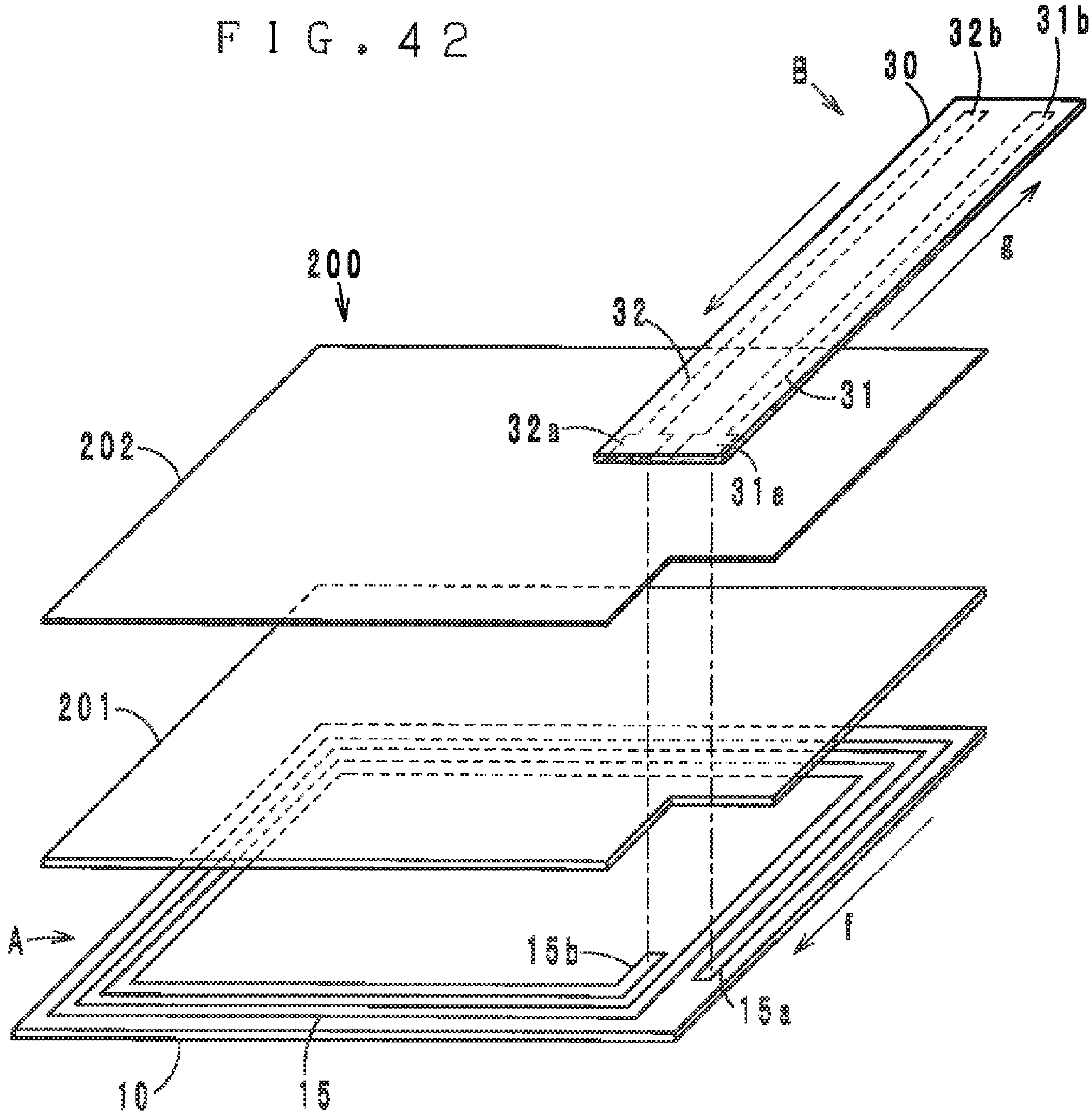

B
30
32b
31b
g
200
32
31
32a
202
31a
201
A
15b
f
15a
10
15

FIG. 43

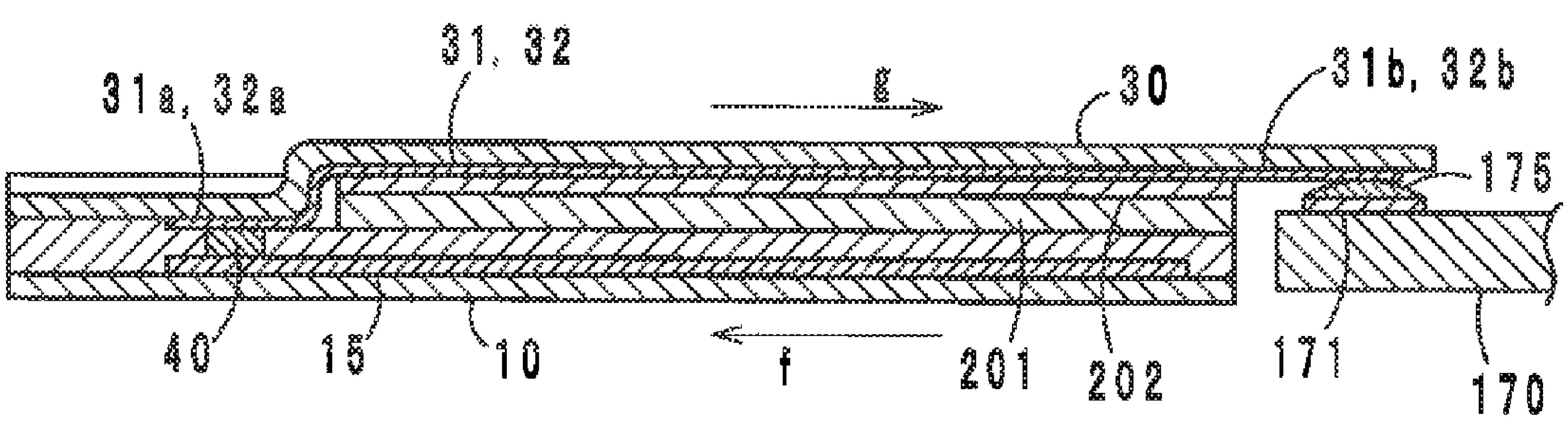

31, 32
31a, 32a
g
30
31b, 32b
175
40
15
10
f
201
202
171
170

FIG. 44

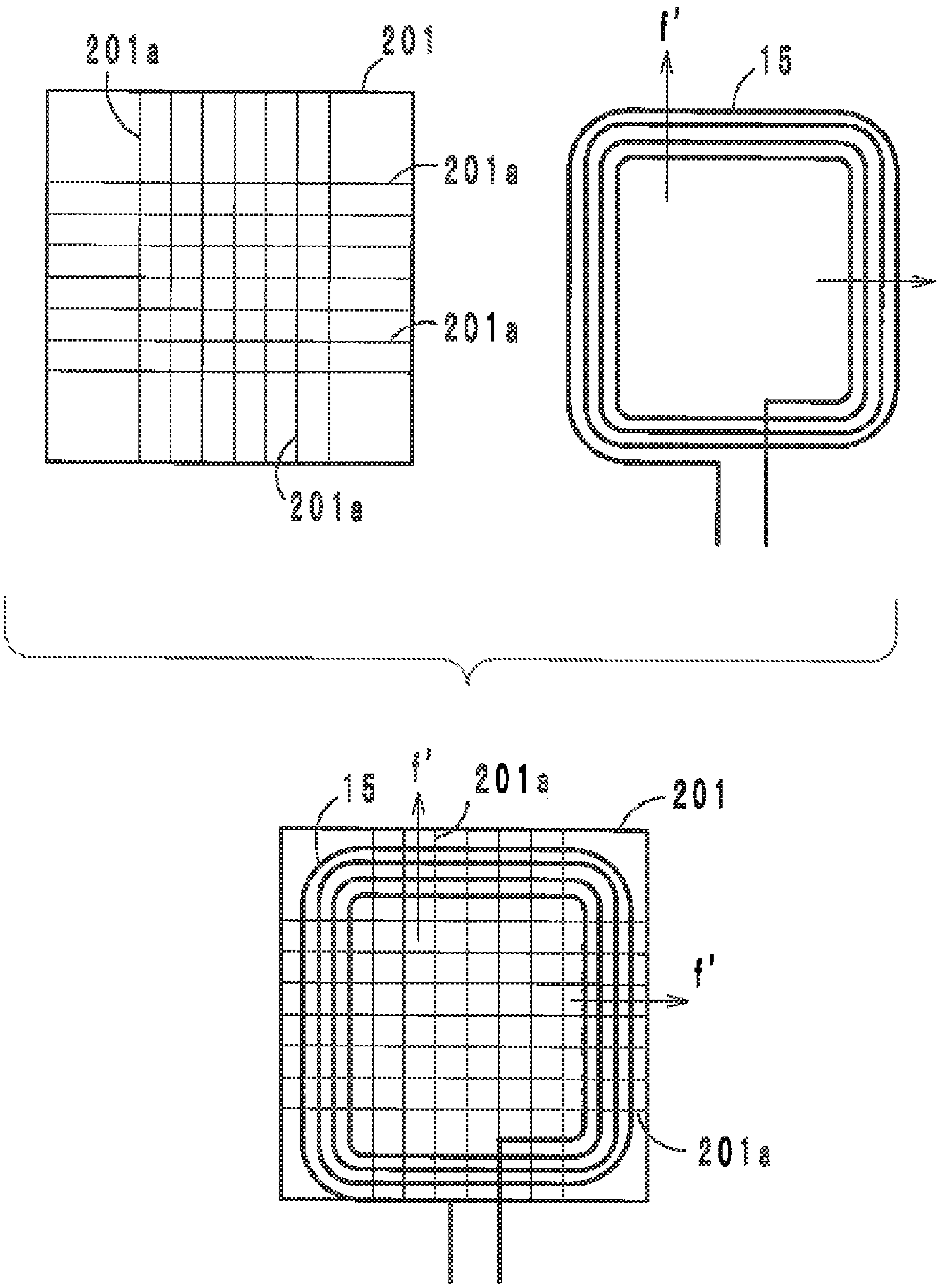


FIG. 45A

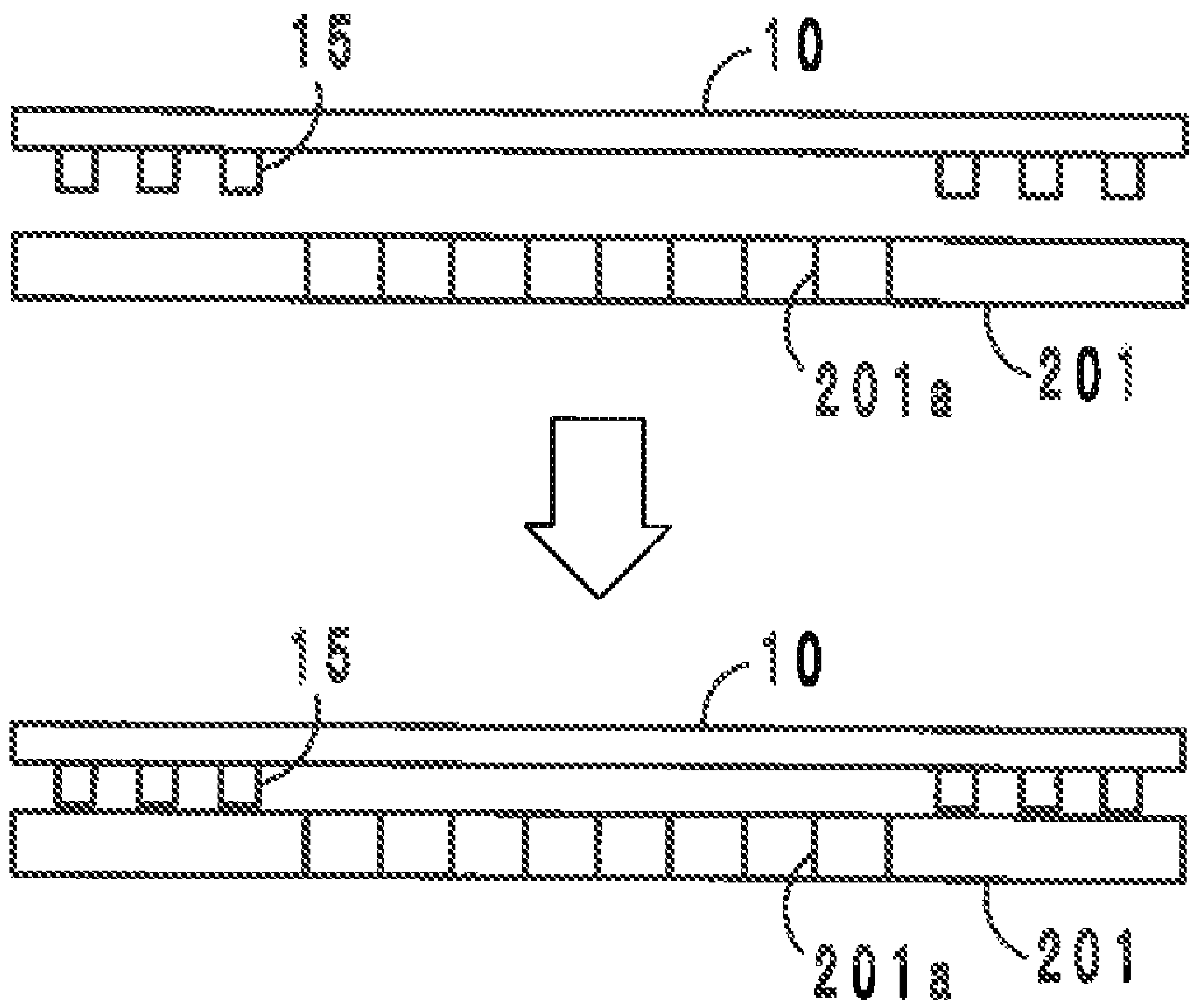
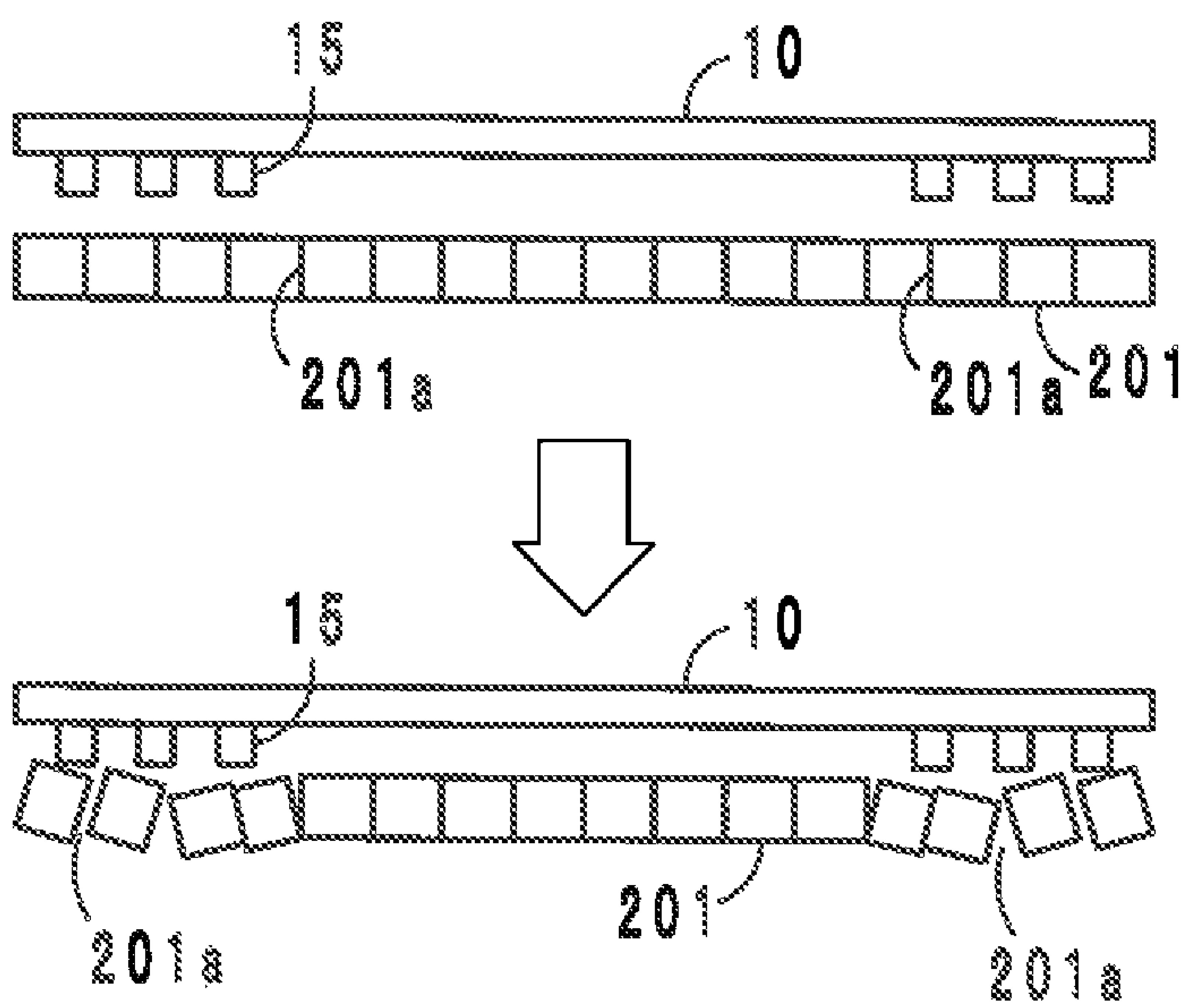


FIG. 45B



ANTENNA DEVICE AND COMMUNICATION TERMINAL APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an antenna device preferably for use in a non-contact communication system, for example, an NFC (near field communication) system, and a communication terminal apparatus including the antenna device.

2. Description of the Related Art

Recently, an antenna device for use in a non-contact communication system using a band of 13.56 MHz is incorporated in a portable terminal. In such an antenna device, as disclosed in Japanese Patent Laid-Open Publication No. 2013-13144, Japanese Patent Laid-Open Publication No. 2008-205557 and Japanese Patent No. 4218635, a coil pattern spiraling on a plane is used as an antenna.

In order to connect both ends of the coil pattern spiraling on a plane to other circuits, normally, either of the ends is led to the outside through a via-hole conductor because it is necessary to insulate the ends from each other. However, it takes time and labor to form a via-hole conductor in a substrate, and the formation of a via-hole conductor complicates a manufacturing process.

There is a demand for an antenna device that can avoid degradation of the antenna characteristics. More particularly, in a case where a magnetic member, which is a component of an antenna device, is a sintered body, prevention of cracks of the sintered body is demanded in order to prevent degradation of the antenna characteristics. Also, it is demanded that an antenna device keeps good antenna characteristics even when the antenna device is located at a shorter distance from a communication counterpart, for example, another antenna.

As for an antenna device, further, the following features are required. A magnetic field generated from an antenna pattern is prevented from propagating to other conductor wires. In a bending process, the conductor wires easily bend, and stress concentration is avoided. Wiring disconnection is avoided, and connection reliability is improved. The strength is improved.

SUMMARY OF THE INVENTION

Preferred embodiments of the present invention provide an antenna device that can be manufactured without formation of a via-hole conductor and that is wired simply for connection to an external device, and a communication terminal apparatus.

An antenna device according to a first aspect of various preferred embodiments of the present invention includes a first insulating base portion including a spiral antenna pattern including a first end and a second end; and a second insulating base portion including at least two conductor wires; wherein an insulating layer configured to insulate the conductor wires from the antenna pattern is provided between the first end and the second end of the antenna pattern in a planar view; the conductor wires include electrode portions electrically and mechanically connected to the first end and the second end, respectively, of the antenna pattern by a conductive material; the insulating layer includes a cut or an opening configured such that, before the conductor wires are connected to the antenna pattern, at least one of the first end and the second end of the antenna pattern is exposed toward the conductor wires through the cut or the opening; the conductor wires are connected to the antenna pattern by the conductive material in the cut or the opening of the insulating layer; and the second insulating base portion is more flexible than the first insulating base portion.

A communication terminal apparatus according to a second aspect of various preferred embodiments of the present invention includes the antenna device described above; and a printed wiring board including at least a noise filtering section and a matching section; wherein at least one of the conductor wires included in the second insulating base portion is connected to the noise filtering section or the matching section.

In the antenna device according to the first aspect of various preferred embodiments of the present invention, the first end and the second end of the antenna pattern included in the first insulating base portion are electrically and mechanically connected to the electrode portions of the conductor wires included in the second insulating base portion. Accordingly, it is possible to manufacture the antenna device without using via holes. Also, since the second insulating base portion has excellent flexibility, simple wiring is possible.

In such an antenna device, in order to prevent degradation of the antenna characteristics, it is preferred to inhibit a magnetic field generated by a coil pattern functioning as an antenna from being offset by lead wires. In a case where a sintered body of a magnetic material is located near the antenna, it is necessary to configure and arrange the sintered body in consideration of the possibility of breakage of the sintered body.

Thus, an antenna device that prevents degradation of the antenna characteristics by inhibiting a magnetic field generated by an antenna pattern from being offset by a magnetic field generated by lead wires is demanded.

Also, an antenna device that can diminish the risk of breakage of a sintered body of a magnetic material located near the antenna pattern, thus resulting in an improvement of the antenna characteristics, and significantly reduces or prevents breakage of the sintered body on the communication performance is demanded.

An antenna device according to a third aspect of various preferred embodiments of the present invention includes a first insulating base portion including a spiral antenna pattern including a first end and a second end; and a second insulating base portion including at least two conductor wires; wherein the two conductor wires are electrically connected to the first end and the second end, respectively of the antenna pattern; and in an outermost portion of the spiral antenna pattern and in one of the conductor wires closest to the outermost portion of the antenna pattern, currents flow in the same direction.

In such an antenna device, the outermost portion of the spiral antenna pattern is configured to determine the antenna characteristics to a great degree. In the antenna device according to the third aspect, since currents flow in the same direction in the outermost portion of the antenna pattern and in the one of the conductor wires located closest to the outermost portion of the antenna pattern, a magnetic field generated from the outermost portion of the antenna pattern is not offset by a magnetic field generated from the conductor wire closest thereto, and degradation of the antenna characteristics is prevented.

An antenna device according to a fourth aspect of outermost part the present invention includes a first insulating base portion including a spiral antenna pattern including a first end and a second end; a second insulating base portion including at least two conductor wires; and a magnetic member located between the first insulating base portion and the second insulating base portion; wherein the two conductor wires are electrically connected to the first end and the second end, respectively, of the antenna pattern; and in an outermost portion of the spiral antenna pattern and in one of the conductor wires closest to the outermost portion of the antenna pattern, currents flow in opposite directions.

In the antenna device according to the fourth aspect, since the magnetic member is located near the antenna pattern, the magnetic field around the antenna pattern is strengthened. Also, since currents flow in opposite directions in the outermost portion of the spiral antenna pattern and in one of the conductor wires closest to the outermost portion of the antenna pattern, there is no possibility that a magnetic field generated from the outermost portion of the antenna pattern and a magnetic field generated from the conductor wire closest thereto flow in the same direction inside the magnetic member, and degradation of the antenna characteristics is prevented.

An antenna device according to a fifth aspect of outermost part the present invention includes a first insulating base portion including a spiral antenna pattern including a first end and a second end; a second insulating base portion including at least two conductor wires; and a magnetic member located between the first insulating base portion and the second insulating base portion; wherein the two conductor wires are electrically connected to the first end and the second end, respectively, of the antenna pattern; the magnetic member includes a sintered body of a magnetic material and a supporting sheet stuck on the sintered body of the magnetic material, the sintered body being located on a side of the first insulating base portion, and the supporting sheet being located on a side of the second insulating base portion.

In the antenna device according to the fifth aspect, since the supporting sheet is stuck on the sintered body of the magnetic material, the sintered body does not break easily. Since the sintered body is located on a side of the first insulating base portion (that is, located on a side of the antenna pattern), the magnetic flux density of the antenna pattern is increased, and the antenna characteristics are improved.

An antenna device according to a sixth aspect of various preferred embodiments of the present invention includes a first insulating base portion including a spiral antenna pattern including a first end and a second end; a second insulating base portion including at least two conductor wires; and a sintered body of a magnetic material located between the first insulating base portion and the second insulating base portion; wherein the two conductor wires are electrically connected to the first end and the second end, respectively, of the antenna pattern; slits are provided in the sintered body in a matrix such that in an area near the antenna pattern, and the slits extend parallel or substantially parallel to the direction of a magnetic flux generated from the antenna pattern.

In the antenna device according to the sixth aspect, in consideration of the fragility of the sintered body of the magnetic material, slits are preliminarily made in the sintered body. In an area near the antenna pattern, the slits extend parallel or substantially parallel to the direction of a magnetic flux generated from the antenna pattern. Therefore, the slits do not block the magnetic field generated from the antenna pattern, and a reduction in the magnetic permeability is prevented.

An antenna device according to a seventh aspect of various preferred embodiments of the present invention includes a first insulating base portion including a spiral antenna pattern including a first end and a second end; a second insulating base portion including at least two conductor wires; and a sintered body of a magnetic material located between the first insulating base portion and the second insulating base portion; wherein the two conductor wires are electrically connected to the first end and the second end, respectively, of the antenna pattern; and slits are provided in the sintered body in a matrix except for an area near the antenna pattern.

In a case where a sintered body is stuck on the first insulating base portion, it is likely that the widths of the slits may change, which results in a change in the permeability. In the antenna device according to the seventh aspect, in the area near the antenna pattern, the slits in a matrix are not provided. Therefore, in the area near the antenna pattern, it is unlikely that the widths of the slits change, and a reduction in the permeability is prevented.

An antenna device according to an eighth aspect of various preferred embodiments of the present invention includes a first insulating base portion including a spiral antenna pattern; and a second insulating base portion including at least two conductor wires, each of the conductor wires including a first end connected to the antenna pattern and a second end connected to an external connection terminal; wherein, when viewed along an axis of a spiral of the antenna pattern, the conductor wires overlap with the antenna pattern; and in the overlapping portion of the antenna pattern and the conductor wires, a magnetic sheet is provided between the antenna pattern and the conductor wires.

In the antenna device according to the eighth aspect, since the magnetic sheet is provided between the antenna pattern and the conductor wires, a magnetic field generated by the antenna pattern is prevented from propagating to the conductor wires, and degradation of the antenna characteristics is prevented. It is preferred that the magnetic sheet covers the coil open portion of the antenna pattern. Also, it is preferred that the second insulating base portion is located within the outer edge of the first insulating base portion when viewed along the axis of spiral of the antenna pattern. Accordingly, the antenna device is capable of being significantly reduced in size.

Further, it is preferred that the portion of the second antenna insulating base portion where the conductor wires are connected to the antenna pattern is thinner than the portion of the second antenna insulating base portion where the external connection terminals are provided. The thinner portion is more flexible and bends more easily, and breakage of the conductor wires is reliably prevented. Also, the second insulating base portion is preferably a laminate of insulating base plates, and the conductor wires are preferably located between the insulating base plates. In the structure, the conductor wires are protected effectively, and the conductor wires are prevented from coming off from the insulating base plates.

Further, the second insulating base portion is preferably thinner than the first insulating base portion. The first insulating base portion preferably includes a magnetic sheet and a first insulating base including an antenna pattern thereon, and the first insulating base is preferably thinner than the second insulating base portion. Thus, the second insulating base portion is more flexible than the first insulating base portion, and bending of the second insulating base portion is easy. By reducing the thickness of the first insulating base, on which the antenna pattern is provided, the distance between the antenna pattern and a communication counterpart, for example, an antenna, becomes shorter, and the communication performance is improved.

An antenna device according to a ninth aspect of various preferred embodiments of the present invention includes a first insulating base portion including a spiral antenna pattern; and a second insulating base portion including at least two conductor wires, each of the conductor wires including a first end connected to the antenna pattern and a second end connected to an external connection terminal; wherein the first insulating base portion includes a first insulating base on which the antenna pattern is provided; and the first insulating base is thinner than the second insulating base portion.

In the antenna device according to the ninth aspect, since the first insulating base is thinner than the second insulating base portion, the distance between the antenna pattern and a communication counterpart, for example, an antenna is short. Accordingly, the antenna device has improved communication performance. The flexible first insulating base follows the shape of an article to which the antenna device (first insulating base) is stuck, for example, a case. Further, the risk of displacement and/or breakage of the conductor wires is eliminated.

The second insulating base portion preferably includes a second insulating base including the conductor wires thereon, and the first insulating base and the second insulating base are preferably made of the same material. In a case where the first insulating base and the second insulating base are made of the same material, it is unlikely that stress due to the difference in coefficient of thermal expansion occurs on the connection portion between the first insulating base and the second insulating base. It is preferred that a magnetic sheet is stuck on the first insulating base except for connection portions between the antenna pattern and the respective conductor wires. The magnetic sheet is preferably arranged such that the antenna pattern is sandwiched between the magnetic sheet and the first insulating base. The provision of the magnetic sheet results in effective protection of the antenna pattern.

It is preferred that the line widths of at least the portions of the conductor wires connected to the antenna pattern are greater than the line width of the antenna pattern. With this arrangement, wire disconnection is unlikely to occur on the connection portions between the antenna pattern and the respective conductor wires, and the connection reliability is improved.

In an antenna device according to a tenth aspect, the external connection terminals of the conductor wires are drawn to a front surface and/or a back surface of the second insulating base portion through interlayer connection conductors. By applying a heating member, for example, a heater bar to the external connection terminals drawn to either the front surface or the back surface of the second insulating base portion, the external connection terminals located on the opposite side of the second insulating base portion are connected to lands on a printed wiring board. Alternatively, by applying a heating member to the external connection terminals exposed on either the front surface or the back surface of the second insulating base portion, the external connection terminals exposed on the opposite side of the second insulating base portion are connected to lands on a printed wiring board.

According to various preferred embodiments of the present invention, it is possible to manufacture an antenna device without forming a via-hole conductor, and the antenna device has simple wiring for connection to an external device.

According to various preferred embodiments of the present invention, also, a magnetic member hardly breaks, and even if the magnetic material breaks, the breakage has no effects or only negligible effects on the antenna characteristics.

The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded view of an antenna device according to a first preferred embodiment of the present invention.

FIGS. **2**A and **2**B are sectional views of the antenna device, FIG. **2**A illustrating the antenna device in a disassembled state, and FIG. **2**B illustrating the antenna device in an assembled state.

FIG. **3** is a sectional view indicating another shape of an antenna pattern.

FIG. **4** is a plan view illustrating a step of a manufacturing process of the antenna device.

FIG. **5** is a plan view illustrating another connection form between the antenna pattern and a conductor wire.

FIG. **6** is a plan view illustrating still another form of connecting the antenna pattern to a conductor wire.

FIG. **7** is a plan view of a communication terminal apparatus illustrating a first exemplary form of incorporation of the antenna device in the communication terminal device.

FIG. **8** is a circuit diagram of a portion of the communication terminal device.

FIG. **9** is a perspective view of an antenna device according to a second preferred embodiment of the present invention.

FIG. **10** is a plan view of a communication terminal apparatus illustrating a second exemplary form of incorporation of the antenna device in the communication terminal device.

FIG. **11** is a plan view of a communication terminal apparatus illustrating a third exemplary form of incorporation of the antenna device in the communication terminal device.

FIG. **12** is a perspective view of an antenna device according to a third preferred embodiment of the present invention.

FIG. **13** is a perspective view of an antenna device according to a fourth preferred embodiment of the present invention.

FIGS. **14**A and **14**B are sectional views of an antenna device, illustrating a first example of reinforcement of connection portions.

FIGS. **15**A through **15**D illustrate a process of forming a though hole.

FIG. **16** is a sectional view of the antenna device, illustrating a second example of reinforcement of connection portions.

FIG. **17** is a sectional view of the antenna device, illustrating a third example of reinforcement of connection portions.

FIG. **18** is a sectional view of the antenna device, illustrating a fourth example of reinforcement of connection portions.

FIG. **19** is a sectional view of the antenna device, illustrating a fifth example of reinforcement of connection portions.

FIG. **20** is a perspective view of an antenna device according to a fifth preferred embodiment of the present invention.

FIG. **21** is a plan view of the antenna device according to the fifth preferred embodiment of the present invention.

FIG. **22** is a sectional view of the antenna device illustrated in FIG. **21**

FIG. **23** is a perspective view of an antenna device according to a first modification to the fifth preferred embodiment of the present invention.

FIG. **24** is a perspective view of an antenna device according to a second modification to the fifth preferred embodiment of the present invention.

FIG. **25** is a sectional view of the antenna device illustrated in FIG. **24**.

FIG. **26** is a sectional view of an interlayer connection conductor.

FIG. **27** is a sectional view of an antenna device according to a third modification to the fifth preferred embodiment of the present invention.

FIG. **28** is a sectional view of an antenna device according to a fourth modification to the fifth preferred embodiment of the present invention.

FIG. **29** is a perspective view of an antenna device according to a sixth preferred embodiment of the present invention.

FIG. **30** is a sectional view of the antenna device illustrated in FIG. **29**.

FIG. **31** is a perspective view of an antenna device according to a seventh preferred embodiment of the present invention.

FIG. **32** is a plan view of the antenna device according to the seventh preferred embodiment of the present invention.

FIG. **33** is a sectional view of the antenna device illustrated in FIG. **32**.

FIG. **34** is a sectional view of an antenna device according to a first modification to the seventh preferred embodiment of the present invention.

FIG. **35** is a sectional view of an antenna device according to a second modification to the seventh preferred embodiment of the present invention.

FIG. **36** is a sectional view of an antenna device according to a third modification to the seventh preferred embodiment of the present invention.

FIG. **37** is a sectional view of an antenna device according to a fourth modification to the seventh preferred embodiment of the present invention.

FIG. **38** is a sectional view of an antenna device according to a fifth modification to the seventh preferred embodiment of the present invention.

FIG. **39** is a sectional view of the antenna device illustrated in FIG. **38**.

FIG. **40** is a perspective view of an antenna device according to an eighth preferred embodiment of the present invention.

FIG. **41** is a sectional view of the antenna device illustrated in FIG. **40**.

FIG. **42** is an exploded perspective view of an antenna device, illustrating a first example of the position and the configuration of a ferrite sintered body.

FIG. **43** is a sectional view of the antenna device illustrated in FIG. **42**.

FIG. **44** is a plan view of an antenna device, illustrating a second example of the position and the configuration of a ferrite sintered body.

FIG. **45**A indicates sectional views of an antenna device, illustrating a third example of the position and the configuration of a ferrite sintered body, and FIG. **45**B indicates sectional views of an antenna device, illustrating a comparative example of the position and the configuration of a ferrite sintered body.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Antenna devices and communication terminal apparatuses according to some preferred embodiments of the present invention are hereinafter described with reference to the drawings. In the drawings, the same components and elements are identified with the same reference symbols, and descriptions of the same components and elements are not repeated.

First Preferred Embodiment

An antenna device **1** according to a first preferred embodiment of the present invention illustrated in FIG. **1** is preferably for use in an NFC system of an HF band, an RFID system or the like, for example. The antenna device **1** preferably includes a first insulating base portion A and a second insulating base portion B. The first insulating base portion A includes a first insulating base **10**, an antenna pattern **15**, an insulating adhesive layer **20**, and a ferrite sheet **25**. The antenna pattern **15** is configured to spiral on a main surface of the first insulating base **10** with its first end **15***a* and its second end **15***b* located on the main surface. The ferrite sheet **25** is a magnetic sheet. The second insulating base portion B includes a second insulating base **30**, and conductor wires **31** and **32** on a back surface of the second insulating base **30**.

The conductor wire **31** includes an electrode portion **31***a* and an external connection terminal **31***b*. The electrode portion **31***a* of the conductor wire **31** is soldered (electrically and mechanically connected) to the first end **15***a* of the antenna pattern **15** on a planar surface. The conductor wire **32** includes an electrode portion **32***a* and an external connection terminal **32***b*. The electrode portion **32***a* of the conductor wire **32** is soldered (electrically and mechanically connected) to the second end **15***b* of the antenna pattern **15** on a planar surface.

The first insulating base **10** and the second insulating base **30** are preferably made of polyimide resin. However, any other material, for example, liquid crystal polymer or the like may be used for the bases **10** and **30**. In a planar view, the second insulating base **30** is elongated and protrudes outward from the first insulating base **10**. The second insulating base portion B is more flexible than the first insulating base portion A. In a case where the first insulating base **10** and the second insulating base **30** are made of the same material, stress due to a difference in coefficient of thermal expansion is unlikely to occur at the connection portion between the bases **10** and **30**.

The antenna pattern **15**, and the conductor wires **31** and **32** are formed preferably by etching copper foils formed on the bases **10** and **30**, respectively. However, any other method may be used to form the antenna pattern **15**, and the conductor wires **31** and **32**.

The insulating adhesive layer **20** is configured to insulate the antenna pattern **15** from the conductor wire **32**, which crosses the antenna pattern **15** in a planar view, so as to prevent short circuiting. The insulating adhesive layer **20** preferably is preliminarily formed by pattern printing on the first insulating base **10**, on which the antenna pattern **15** is formed, or on the back surface of the second insulating base

30, on which the conductor wires **31** and **32** are formed. Alternatively, the insulating adhesive layer **20** may be an adhesive sheet stuck on the insulating base **10** or **30**. The insulating adhesive layer **20** is also used to bond the ferrite sheet **25** to the first insulating base **10**.

The second insulating base **30** is bonded onto the first insulating base **10** via the insulating adhesive layer **20**. Then, the first end **15***a* and the second end **15***b* of the antenna pattern **15** are soldered to the electrode portion **31***a* of the conductor wire **31** and to the electrode portion **32***a* of the conductor wire **32**, respectively, through cuts **20***a* and **20***c* made in the insulating adhesive layer **20** and a cut **25** made in the ferrite sheet **25** (see solder **40** in FIGS. **2**A and **2**B). The insulating adhesive layer **20** includes a bridge **20***b* in the cut **20***a* so as to insulate the electrode portions **31***a* and **32***a* from each other.

The insulating adhesive layer **20** including the cuts **20***a* and **20***c* preferably are formed by pattern printing, for example. Alternatively, an adhesive sheet with the cuts **20***a* and **20***c* preliminarily made therein may be used as the insulating adhesive layer **20**. During a heating process such as a reflow soldering process, the insulating adhesive sheet **20** is slightly pressed to be bonded onto the first insulating base **10**. The insulating adhesive layer **20** flows due to the heat. In this moment, the bridge **20***b* for insulation flows to cover a portion of the antenna pattern **15** and to come into a space between the first end **15***a* and the second end **15***b* of the antenna pattern **15**, in a planar view, on the first insulating base **10**. Due to the bridge **20***b*, a short circuit of the antenna pattern **15** by the conductor wire **32** is prevented.

In the antenna device **1** having the structure above, the first and the second ends **15***a* and **15***b* of the antenna pattern **15** provided on the main surface of the first insulating base **10** are electrically and mechanically connected to the electrode portions **31***a* and **32***a* of the conductor wires **31** and **32**, respectively, on a planar surface. Therefore, it is not necessary to use via-hole conductors, and it is easy to manufacture the antenna device **1**. Although the second insulating base portion B protrudes from the first insulating base portion A, only simple wiring is required because the second insulating base portion B has an excellent flexibility.

The cut **25***a* of the ferrite sheet **25** allows a bond of the first insulating base **10** and the second insulating base **30** to each other. Specifically, through the cut **25***a* of the ferrite sheet **25** and the cuts **20***a* and **20***c* of the insulating adhesive layer **20**, the first and the second ends **15***a* and **15***b* of the antenna pattern **15** are exposed to outside. The ferrite sheet **25** prevents leakage of a magnetic field generated from the antenna pattern **15** and strengthens magnetic coupling so that external magnetic waves and high-frequency signals are suitably input to the antenna pattern **15**. Especially both sides of the cut **25***a* of the ferrite sheet **25** prevent leakage of the magnetic field radiated from the antenna pattern **15**.

When a metal object is put close to the antenna pattern **15**, an eddy current occurs on the metal object due to the magnetic field radiated from the antenna pattern **15**, and thus, the energy of the antenna pattern **15** may be weakened. According to this preferred embodiment, however, the provision of the ferrite sheet **25** significantly reduces or prevents such an energy loss. This effect of reducing the energy loss is made stronger by adding a magnetic material, for example, a magnetic powder to the material of the insulating adhesive layer **20**.

Exemplary materials and thicknesses of the components of the antenna device **1** are described with reference to FIGS. **2**A and **2**B. FIGS. **2**A and **2**B are sectional views of the antenna device **1** along the line X-X indicated in FIG. **1**, and illustrates the relation of connection in an easy-to-understand manner. The sectional views illustrated in FIGS. **2** through **11** are along the same line.

The first insulating base **10** preferably is made of polyimide resin, and the thickness D1 thereof is preferably within a range from about 10 μm to about 15 μm, for example. The antenna pattern **15** preferably is made of a copper foil, and the thickness D2 thereof preferably is within a range from about 15 μm to about 35 μm, for example. The insulating adhesive layer **20** is preferably made of epoxy resin, and the thickness D3 thereof is preferably within a range from about 25 μm to about 45 μm, for example. The ferrite sheet **25** preferably is a sintered body of a Ni—Zn-based material, and the thickness D4 thereof preferably is within a range from about 100 μm to about 150 μm, for example. The second insulating base **30** is preferably made of polyimide resin, and the thickness D5 thereof preferably is within a range from about 50 μm to about 100 μm, for example. The conductor wires **31** and **32** are preferably made of a copper foil, and the thickness D6 thereof preferably is within a range from about 10 μm to about 20 μm, for example. The solder **40** is preliminarily coated on the conductor wires **31** and **32**, and the thickness D7 thereof preferably is within a range from about 10 μm to about 30 μm, for example.

More specifically, in this preferred embodiment, the thicknesses D1 through D7 preferably are as follows. The thickness D1 of the first insulating base **10** preferably is about 10 μm, and the thickness D2 of the antenna pattern **15** preferably is about 20 μm, for example. The thickness D3 of the insulating adhesive layer **20** preferably is about 30 μm, and the thickness D4 of the ferrite sheet **25** preferably is about 120 μm, for example. The thickness D5 of the second insulating base **30** preferably is about 100 μm, and the thicknesses of the conductor wires **31** and **32** are about 16 μm, for example. The thickness D7 of the solder **40** preferably is about 10 μm, for example. In the structure having the thicknesses, the second insulating base portion B is more flexible than the first insulating base portion A. The thicknesses of the components seen in the sectional views in FIGS. **2**A, **2**B and **3** are not necessarily consistent with the values above.

It is preferred that the thickness D3 of the insulating adhesive layer **20** is smaller than the thickness D4 of the ferrite sheet **25**. When the thickness D3 of the insulating adhesive layer **20** is small, it is easy to bond the conductor wires **31** and **32** to the pattern **15** by the solder **40** with the insulating adhesive layer **20** held between. Also, it is preferred that the thickness D3 of the insulating adhesive layer **20** is greater than the thickness D2 of the antenna pattern **15**. With this arrangement, an undesired electrical connection (short circuit) between the antenna pattern **15** and the conductor wire **31** or **32** is prevented.

It is preferred that the thickness D1 of the first insulating base **10** is smaller than the thickness D2 of the antenna pattern **15**. With this arrangement, it is possible to reduce the thickness of the antenna device **1** as a whole while reducing the conductor loss.

As seen in FIG. **3**, a cross section (a section cut in the widthwise direction) of the antenna pattern **15** preferably has a trapezoidal shape with a greater lower base and a smaller upper base. Reflow soldering by use of the solder **40** is carried out while the first insulating base portion A and the second insulating base portion B are pressed in the thickness direction with the insulating adhesive layer **20** placed between the portions A and B. In this moment, the pressure of the flowing insulating adhesive layer **20** acts on the pattern **15** in the directions indicated by arrows in FIG. **3**. If the cross-sectional shape of the pattern **15** is rectangular, the pattern **15** will block the flow of the adhesive layer **20**, and the pressure of the flowing adhesive layer **20** will act strongly on the pattern **15**, such that the pattern **15** may come off from the first insulating base **10**.

In a case where the cross-sectional shape of the antenna pattern **15** is trapezoidal, the pitch P of the upper surface of the spiral antenna pattern **15** is wider. Thus, the fluidity of the adhesive layer **20** becomes greater, and the pressure applied on the pattern **15** is weakened. Accordingly, it is unlikely that the pattern **15** comes off from the first insulating base **10**. The greater fluidity of the adhesive layer **20** results in good connection by the solder **40**. In order to prevent detachment of the pattern **15** from the first insulating base **10** due to the pressure of the flowing adhesive layer **20**, it is also possible to increase the surface roughness of the surface of the antenna pattern **15** in contact with the first insulating base **10** (that is, the lower surface of the antenna pattern **15**). The increase in the surface roughness of the surface of the antenna pattern **15** in contact with the first insulating base **10** increases the joint strength between the base **10** and the pattern **15**. The increase in the pitch P of the upper surface of the antenna pattern **15** causes an increase in the conductor spacing, and this reduces energy loss caused by line capacity.

It is possible to form the antenna pattern **15** into a trapezoidal cross-sectional shape, for example, by adjusting the etching speed during an etching process to form the antenna pattern **15**.

A non-limiting example of a method of manufacturing will now be described. First, as illustrated in FIG. **4**, antenna patterns **15** are formed in a matrix on a large mother sheet **51**, and pairs of conductor wires **31** and **32** are formed in a matrix on a large mother sheet **52**. The mother sheet **51** is cut into a plurality of first insulating bases **10** such that each of the first insulating bases **10** includes an antenna pattern **15**, and the mother sheet **52** is cut into a plurality of second insulating bases **30** such that each of the second insulating bases **20** includes a pair of conductor wires **31** and **32**. Each one of the bases **30** is laminated and bonded to each one of the bases **10** via the insulating adhesive layer **20** with the cuts **20***a* and **20***c* made therein and the ferrite sheet **25** with the cut **25***a* made therein. In this way, a large number of bases **10** and a large number of bases **30** can be obtained at one time.

The antenna pattern **15** may be connected to the conductor wires **31** and **32** as illustrated in FIG. **5**. Specifically, the second insulating base **30** may be located on a corner portion of the first insulating base **10**. Also, it is possible to connect the antenna pattern **15** to the conductor wires **31** and **32** as illustrated in FIG. **6**. Specifically, the second insulating base **30** may be located on the upper half in FIG. **6** of the first insulating base **10** such that the second insulating base **30** will not protrude outward from the first insulating base **10**.

In either of the connection configurations illustrated in FIGS. **5** and **6**, electrical and mechanical connections on a planar surface between the first end **15***a* of the antenna pattern **15** and the electrode portion **31***a* of the conductor wire **31** and between the second end **15***b* of the antenna pattern **15** and the electrode portion **32***a* of the conductor wire **32** are attained without causing a short circuit.

Referring to FIG. **7**, a first exemplary communication terminal apparatus **61** including the antenna device **1** is described. The communication terminal apparatus **61** is, for example, a cell phone, and the antenna device **1** is stuck to the bottom of a case **65** via an adhesive layer **66**. The second insulating base **30** is folded back 180 degrees, and the terminals **31***b* and **32***b* of the conductor wires **31** and **32** are electrically connected via solder **71** to a matching element (capacitor) **72** mounted on a printed wiring board **70**. Further, a noise filter **73** and other elements are mounted on the printed wiring board **70**.

As illustrated in FIG. **8**, a circuit in the connection portion of the communication terminal apparatus **61** includes a noise filter section **81** connected to an IC **80**, and a matching section **82**. The antenna device **1** is connected to the matching section **82**. The conductor wire **31** is used for connection to the matching section **82**, and the conductor wire **32** is used for connection to a ground.

Second Preferred Embodiment

As illustrated in FIG. **9**, in an antenna device **2** according to a second preferred embodiment of the present invention, the second insulating base **30** is relatively thick and plastic, and is folded back by plastic deformation at or substantially at the center. The antenna device **2** is connected to a printed wiring board in a communication terminal apparatus in a similar manner as illustrated in FIG. **7** although the connection between the antenna device **2** and the printed wiring board is not illustrated in the drawings.

In a second exemplary communication terminal apparatus **62**, the antenna device **1** has the first and the second insulating bases **10** and **30** connected to each other in the configuration illustrated in FIG. **6**. As illustrated in FIG. **10**, in the second exemplary communication terminal apparatus **62**, the second insulating base **30** is folded back immediately above the first insulating base **10**, and the terminals **31***b* and **32***b* of the conductor wires **31** and **32** are connected via solder **71** to a matching element on a printed wiring board **70**. In this example, the folded-back second insulating base **30** does not protrude from the outside edge of the first insulating base **10**, and the antenna device **1** is smaller.

In a third exemplary communication terminal apparatus **63**, the antenna device **1** has the first and the second insulating bases **10** and **30** connected to each other in the configuration illustrated in FIG. **6**. In the communication terminal apparatus **63**, as illustrated in FIG. **11**, the end portion of the second insulating base **30** where the terminals **31***b* and **32***b* of the conductor wires **31** and **32** are located is lifted up, and the terminals **31***b* and **32***b* of the conductor wires **31** and **32** are connected via solder **71** to an upper surface of the printed wiring board **70** so as to be connected to a matching element mounted on the printed wiring board **70**. The printed wiring board **70** is supported by a support member (not indicated in the drawings) and is maintained in a position to overlap with the first insulating base **10** in a planar view.

Third Preferred Embodiment

As illustrated in FIG. **12**, in an antenna device **3** according to a third preferred embodiment of the present invention, the second insulating base **30** is bifurcated, and the end portion of the second insulating base **30** where the terminals **31***b* and **32***b* of the conductor wires **31** and **32** are located is slightly lifted up. (The conductor wires **31** and **32** are not seen in FIG. **12** because the conductor wires **31** and **32** are provided on the back surface of the second insulating base **30**.) The conductor wires **31** and **32** are connected to a printed wiring board in a similar manner as illustrated in FIG. **11**.

Fourth Preferred Embodiment

As illustrated in FIG. **13**, in an antenna device **4** according to a fourth preferred embodiment of the present invention, the second insulating base **30** is folded at a plurality of points so as to include a coil-shaped portion, and the coil-shaped portion is gradually lifted up. In this antenna device **4**, the second insulating base **30** has high elastic deformability in the thickness direction. Accordingly, stress concentration on the connection portions where the respective electrode portions **31***a* and **31***b* of the conductor wires **31** and **32** are connected to the antenna pattern **15** is effectively prevented, and the second insulating base **30** is hard to break. The same holds true for the antenna device **3**.

Some examples of reinforcement of the connection portions between the conductor wire **31** and the antenna pattern **15** and between the conductor wire **32** and the antenna pattern **15** will be described below.

As illustrated in FIG. **14**A, through holes **81** are made in the second insulating base **30**, at the locations of the conductor wires **31** and **32**. Thus, as illustrated in FIG. **14**B, solder **40** is filled up in the through holes **81**. Consequently, the connection portions between the conductor wire **31** and the antenna pattern **15** and between the conductor wire **32** and the antenna pattern **15** are reinforced.

The through holes **81** can be formed, for example, by a process as illustrated in FIGS. **15**A through **15**D. Metal films are formed on the upper surface and the lower surface of the base **30** (see FIG. **15**A), and holes **83** are made (see FIG. **15**B). Next, the inner surfaces of the holes **83** and the metal films **82** are coated with films **84** by electroless plating (see FIG. **15**C). Further, the films **84** are coated with films **85** by electrolytic plating (see FIG. **15**D).

The through holes **81** do not always need to have conductors (films **84** and **85**) on their respective inner surfaces, and it may be sufficient to only form holes **83**. In other words, as long as melted solder **40** can be filled up in the holes **83**, it is not necessary to form conductors on the respective inner surfaces of the holes **83**.

In a second example of reinforcement, as illustrated in FIG. **16**, after the conductor wires **31** and **32** are connected to the antenna pattern **15**, the connection portions are covered with a resin material **86**. The resin material **86** functions as a reinforcing member. The resin material **86** may be the same material as the insulating adhesive layer **20**.

A third example of reinforcement is a modification of the second example of reinforcement. As illustrated in FIG. **17**, in the third example, the end portion of the insulating base **30** is stepped (see portion **34** in FIG. **17**), and the stepped end portion **34** is covered with a resin material **86**. Further, the lower surface of the first insulating base **10** is covered with the resin material **86**. In the third example, it is preferred that the same material as the insulating adhesive layer **20** is used as the resin material **86**. In this case, preferably, the resin material **86** is applied onto the connection portions by screen printing, potting or the like, and the resin material **86** is hardened by a UV radiation process, a heating process or the like. In a case where the same material as the insulating adhesive layer **20** is used as the resin material **86**, the insulating adhesive layer **20** and the resin material **86** have the same thermal expansion coefficient, and consequently, the risk that the resin material **86** peels off due to a change in temperature is significantly reduced.

In a fourth example of reinforcement, as illustrated in FIG. **18**, a through hole **91** is made to pierce through the second insulating base **30** from the front surface to the back surface, and the through hole **91** is filled with a resin material **86** for reinforcement. The through hole **91** is formed at a portion where the conductor wires **31** and **32** are not located.

In a fifth example of reinforcement, as illustrated in FIG. **19**, a through hole **92** is made to pierce through the second insulating base **30** from the front surface to the back surface, and a through hole **93** is made to pierce through the first insulating base **10** and the insulating adhesive layer **20** from the front surface to the back surface. The through holes **92** and **93** are filled with a resin material **86** for reinforcement. The through holes **92** and **93** are formed at portions where the conductor wires **31**, **32** and the antenna pattern **15** are not located. In the case of FIG. **19**, the through holes **92** and **93** are located on the same axis. However, such coaxial arrangement of the through holes **92** and **93** is not always necessary.

Fifth Preferred Embodiment

As illustrated in FIG. **20**, an antenna device **5** according to a fifth preferred embodiment of the present invention includes a first insulating base portion A and a second insulating base portion B. The first insulating base portion includes a spiral antenna pattern **15** including a first end **15***a* and a second end **15***b*, and the second insulating base portion B includes at least two conductor wires **31** and **32** provided thereon. The conductor wires **31** and **32** are electrically connected to the first end **15***a* and the second end **15***b*, respectively, of the antenna pattern **15**. In the outermost portion of the antenna pattern **15** and in one of the conductor wires located closest to the outermost portion of the antenna pattern **15** (the conductor wire **31** in the case illustrated in FIGS. **20** and **21**; see the plan view of FIG. **21**), currents flow in the same direction as indicated by arrows f.

Between the first insulating base **10** and the second insulating base **30**, an insulating adhesive layer **20** is provided. More specifically, the insulating adhesive layer **20** is provided only in a portion where the conductor wires **31** and **32** contact with the antenna pattern **15**. In order to ensure the electrical connections between the electrode portion **31***a* of the conductor wire **31** and the first end **15***a* of the antenna pattern **15** and between the electrode portion **32***a* of the conductor wire **32** and the second end **15***b* of the antenna pattern **15**, the insulating adhesive layer **20** includes openings **20***d* (see solder **40** in FIG. **22**). FIG. **22** is a sectional view of the antenna device **5** along the line Y-Y indicated in FIG. **21**. The sectional views that will be made reference to below are sectional views along lines in the same portion.

In the antenna device **5**, the outermost portion of the spiral antenna pattern **15** is configured to determine the antenna characteristics to a great degree. Since currents f flow in the same direction in the outermost portion of the spiral antenna pattern **15** and in the conductor wire **31** located closest to the outermost portion of the spiral antenna pattern **15**, magnetic fields generated there are in the same direction as indicated by arrows f' in FIG. **20**. Accordingly, there is no risk that the magnetic field generated from the outermost portion of the antenna pattern **15** is offset by the magnetic field generated from the conductor wire **31**, and degradation of the antenna characteristics is prevented.

The contact portions (the electrode portions **31***a* and **31***b*) of the conductor wires **31** and **32** to come into contact with the antenna pattern **15** have a greater line width than the antenna pattern **15**. This arrangement allows prevention of disconnection at the contact portions between each of the conductor wires **31** and **32** and the antenna pattern **15**, and results in an improvement in the connection reliability.

According to the fifth preferred embodiment, the second insulating base portion B (the second insulating base **30**) does not always need to be bent when the antenna device **5** is used. As illustrated in FIG. **22**, the terminals **31***b* and **32***b* of the conductor wires **31** and **32** are capable of being connected to lands **171** on a printed wiring board **170** via solder **175** while the second insulating base **30** is stretched out. Therefore, the second insulating base **30** does not need to have excellent flexibility.

First Modification to Fifth Preferred Embodiment

The antenna device **5** according to the fifth preferred embodiment can be modified as illustrated in FIG. **23**. Specifically, a ferrite sheet **180** that is equal or substantially equal in area to the insulating base **10** may be bonded to the back surface of the first insulating base **10** via an insulating adhesive layer **181**. The provision of the ferrite sheet **180** in the vicinity of the antenna pattern **15** allows enhancement of the density of magnetic flux generated from the antenna pattern **15**, and consequently results in an improvement of the antenna characteristics.

Second Modification to Fifth Preferred Embodiment

The antenna device **5** according to the fifth preferred embodiment can be also modified as illustrated in FIGS. **24** and **25**. Specifically, the second insulating base **30** may include a laminate of two base plates **30***a* and **30***b*. Ends of the conductor wires **31** and **32** on the lower surface of the base plate **30***a* may be connected to the terminals **31***b* and **32***b*, respectively, located on the upper surface of the base plate **30***b* via interlayer connection conductors **185**. The provision of the terminals **31***b* and **32***b* on the upper surface of the base **30** allows connection of the conductor wires **31** and **32** to lands **171** on a printed wiring board **170** located on the opposite side of the second insulating base **30** from the first insulating base **10** without bending the second insulating base **30**. Accordingly, there is no risk that breakage of the conductor wires **31** and **32** is caused by bending of the second insulating base **30**. Also, it is possible to connect the terminals **31***b* and **32***b* to the lands **171** easily by applying heat to the end portions of the conductor wires **31** and **32** by use of a heater, for example, a heater bar. In this regard, the heat is transferred to the terminals **31***b* and **32***b*, the solder **175** and the lands **171** via the interlayer connection conductors **185**.

The interlayer connection conductors **185** are preferably formed as follows. As illustrated in FIG. **26**, holes are pierced in the base plates **30***a* and **30***b*, which are made of thermoplastic resin, and the holes are filled with conductive paste **185***a* and **185***b* so as to connect the conductor wire **31** to the terminal **31***b* and connect the conductor wire **32** to the terminal **32***b*. Thereafter, simultaneously with heating and pressure-bonding the base plates **30***a* and **30***b* together, the conductive paste **185***a* and **185***b* is solidified. Thus, the conductive paste **185***a* and **185***b* is joined and electrically conducted together, and the interlayer connection conductors **185** are formed. The interlayer connection conductors **185** may be through holes **81** that can be formed by the process illustrated in FIGS. **15A-15D**. However, in a case where the interlayer connection conductors **185** are via-holes formed by the process illustrated by FIG. **26**, it is not necessary to carry out plating, which is needed in the process of forming a through hole, and the manufacturing process is simplified.

Third Modification to Fifth Preferred Embodiment

The antenna device **5** according to the fifth preferred embodiment can be also modified as illustrated in FIG. **27**. The conductor wires **31** and **32** may be provided on the upper surface of the second insulating base **30**, and ends of the conductor wires **31** and **32** may be connected to the electrode portions **31***a* and **32***a*, respectively, via interlayer connection conductors **186**. On the upper surface of the insulating base **30**, a resist layer **190** is provided.

Fourth Modification to Fifth Preferred Embodiment

The antenna device **5** according to the fifth preferred embodiment can be also modified as illustrated in FIG. **28**. The second insulating base **30** may be a laminate of base plates **30***a* and **30***b*. The conductor wires **31** and **32** are provided on the upper surface of the base plate **30***a*. Ends of the conductor wires **31** and are connected to the electrode portions **31***a* and **32***a*, respectively, provided on the lower surface of the base plate **30***a* via interlayer connection conductors **186**, and the other ends of the conductor wires **31** and **32** are connected to the terminals **31***b* and **32***b*, respectively, provided on the upper surface of the base plate **30***b* via interlayer connection conductors **185**. The electrode portions **31***a* and **31***b* are connected to the first end **15***a* and the second end **15***b*, respectively, of the antenna pattern **15** via solder **40**, and the terminals **31***b* and **32***b* are connected to lands **171** on a printed wiring board **170** via solder **175**.

Sixth Preferred Embodiment

In an antenna device **6** according to a sixth preferred embodiment, as illustrated in FIG. **29**, the conductor wires **31** and **32** are arranged in the second insulating base portion B so as to overlap with each other in the thickness direction (in a planar view). Specifically, the conductor wire **31** is provided on the base plate **30***a*, and the conductor wire **32** is provided on the base plate **30***b*. Further, a resist layer **190** is provided on the base plate **30***b*. As illustrated in FIG. **30**, an end of the conductor wire **31** is connected to the electrode portion **31***a* provided on the lower surface of the base plate **30***a* via an interlayer connection conductor **186**. An end of the conductor wire **32** is connected to the electrode portion **32***a* provided on the lower surface of the base plate **30***a* via an interlayer connection conductor although it is not illustrated in FIG. **30**. The other end of the conductor wire **31** is connected to the terminal **31***b* provided on the upper surface of the base plate **30***b* via an interlayer connection conductor **185** provided in the base plate **30***b*.

The other portions of the sixth preferred embodiment preferably have the same structure as the fifth preferred embodiment and the modifications thereto. In the structure, as described in connection with the fifth preferred embodiment, in the outermost portion of the antenna pattern **15** and in the conductor wire **31** located closest to the outermost portion of the antenna pattern **15**, currents flow in the same direction as indicated by arrows f. Accordingly, there is no risk that a magnetic field generated from the outermost portion of the antenna pattern **15** is offset by a magnetic field generated from the conductor wire **31**, and degradation of the antenna characteristics is prevented.

Antenna Device According to Seventh Preferred Embodiment

As illustrated in FIG. **31**, an antenna device **7** according to a seventh preferred embodiment includes a first insulating base portion A, a second insulating base portion B, and a magnetic member (ferrite sheet **25**) provided between the first insulating base portion A and the second insulating base portion B. The first insulating base portion includes a spiral antenna pattern **15** including a first end **15***a* and a second end **15***b*, and the second insulating base portion B includes at least two conductor wires **31** and **32** provided thereon. In the antenna device **7** according to the seventh preferred embodiment, the antenna pattern **15** spirals on the first insulating base **10** in a direction opposite to those of the antenna devices according to the preferred embodiments above. The two conductor wires **31** and **32** are electrically connected to the first end **15***a* and the second end **15***b*, respectively, of the antenna pattern **15**. In the outermost portion of the antenna pattern **15** and in one of the conductor wires that is located closest to the outermost portion of the antenna pattern **15** (the conductor wire **31** in the case illustrated in FIGS. **31** and **32**; see the plan view of FIG. **32**), currents flow in opposite directions as indicated by arrows f and g.

Further, an insulating adhesive layer **20** is provided between the first insulating base **10** and the ferrite sheet **25**. More specifically, the ferrite sheet **25** and the insulating adhesive layer **20** are equal or substantially equal in area to the first insulating base **10**. In order to ensure electrical connections between the electrode portion **31***a* of the conductor wire **31** and the first end **15***a* of the antenna pattern **15** and between the electrode portion **32***a* of the conductor wire **32** and the first end **15***b* of the antenna pattern **15** (see solder **40** in FIG. **33**), the insulating adhesive layer **20** includes openings **20***d*. For the same purpose, the ferrite sheet **25** includes a cut **25***a*.

In the antenna device **7**, the magnetic member (ferrite sheet **25**) is provided in the vicinity of the antenna pattern **15**, and therefore, the magnetic field around the antenna pattern **15** is strengthened. Also, in the outermost portion of the antenna pattern **15** and in one of the conductor wires that is located closest to the outermost portion of the antenna pattern **15** (the conductor wire **31** in the case illustrated in FIGS. **31** and **32**; see the plan view of FIG. **32**), currents f and g flow in opposite directions, and therefore, a magnetic field f' generated from the outermost portion of the antenna pattern **15** and a magnetic field g' generated from the conductor wire **31** located closest to the outermost portion of the antenna pattern **15** are in the same direction inside the magnetic member (ferrite sheet **25**) and are not offset by each other. Accordingly, degradation of the antenna characteristics is prevented. Further, the antenna device **7** according to the seventh preferred embodiment has the same effects as the antenna device **5** according to the fifth preferred embodiment.

First Modification to Seventh Preferred Embodiment

The antenna device **7** according to the seventh preferred embodiment can be modified as illustrated in FIG. **34**. Specifically, ends of the conductor wires **31** and **32** on the lower surface of the second insulating base **30** may be connected to the terminals **31***b* and **32***b*, respectively, on the upper surface of the insulating base **30** via interlayer connection conductors **185**. The provision of the terminals **31***b* and **32***b* on the upper surface of the insulating base **30** allows connection of the terminals **31***b* and **32***b* to lands **171** on a printed wiring board **170** located on the opposite side of the second insulating base **30** from the first insulating base **10** via solder **175** without bending the second insulating base **30**. Accordingly, there is no risk that breakage of the conductor wires **31** and **32** is caused by bending of the second insulating base **30**.

Second Modification to Seventh Preferred Embodiment

The antenna device **7** according to the seventh preferred embodiment can be also modified as illustrated in FIG. **35**.

In the modification illustrated in FIG. **35**, the conductor wires **31** and **32** are provided on the upper surface of the second insulating base **30**, and ends of the conductor wires **31** and **32** are connected to the electrode portions **31***a* and **32***a*, respectively, via interlayer connection conductors **186**. On the upper surface of the insulating base **30**, a resist layer **190** is provided.

Third Modification to Seventh Preferred Embodiment

The antenna device **7** according to the seventh preferred embodiment can be also modified as illustrated in FIG. **36**. In the modification illustrated in FIG. **36**, the second insulating base **30** preferably includes a laminate of base plates **30***a* and **30***b*. The conductor wires **31** and **32** are provided on the upper surface of the base **30***a*. Ends of the conductor wires **31** and **32** are connected to the electrode portions **31***a* and **32***a* provided on the lower surface of the base plate **30***a*, respectively, via interlayer connection conductors **186**, and the other ends of the conductor wires **31** and **32** are connected to the terminals **31***b* and **32***b* on the upper surface of the base plate **30***b*, respectively, via interlayer connection conductors **185**. The electrode portions **31***a* and **31***b* are connected to the ends **15***a* and **15***b*, respectively, of the antenna pattern **15** via solder **40**. The terminals **31***b* and **32***b* are connected to lands **171** on a printed wiring board **170** via solder **175**.

Fourth Modification to Seventh Preferred Embodiment

The antenna device **7** according to the seventh preferred embodiment can be also modified as illustrated in FIG. **37**. In the modification illustrated in FIG. **37**, the second insulating base **30** preferably is a three-layered base (a laminate of base plates **30***a*, **30***b* and **30***c*). Specifically, on the base plate **30***b* illustrated in FIG. **36**, further, another base plate **30***c* is laminated. From an end of the conductor wire **31**, terminal portions **31***b* and **31***b*' are led out to the lower surface and the upper surface, respectively, of the second insulating base **30** via an interlayer connection conductor **185**. From an end of the conductor wire **32**, terminal portions **32***b* and **32***b*' are led out to the lower surface and the upper surface, respectively, of the second insulating base **30** via an interlayer connection conductor **185**. The terminals **31***b* and **32***b* are connected to lands **171** on a printed wiring board **170** via solder **175**. It is possible to solder the terminals **31***b* and **32***b* to the lands **171** easily by applying heat to the terminal portions **31***b*' and **32***b*' by use of a heater bar. In this regard, the heat is transferred to the terminals **31***b* and **32***b*, the solder **175** and the lands **171** via the interlayer connection conductors **185**.

The portion of the second insulating base **30** at and around the connection portions between the antenna pattern **15** and the conductor wires **31** and **32** includes a smaller number of layers and is thinner than the portion where the terminals **31***b* and **32***b* are located. The thinner portion is more flexible and is easy to bend, and therefore, breakage of the conductor wires **31** and **32** prevented. The second insulating base **30** is multilayered (three-layered in this modification), and the conductor wires **31** and **32** are located between the layers. With this arrangement, the conductor wires **31** and **32** is protected effectively.

The second insulating base portion B is thinner than the first insulating base portion A. The first insulating base portion A includes a first insulating base **10**, an antenna pattern **15** provided on a main surface of the first insulating base **10**, an insulating adhesive layer **20** and a magnetic sheet **25**. The second insulating base portion B includes the second insulating base **30** (**30***a*, **30***b* and **30***c*), and the conductor wires **31** and **32** provided in the second insulating base **30**. The first insulating base **10** is thinner (has a smaller thickness) than the second insulating base **30**. Accordingly, the second insulating base portion B is more flexible than the first insulating base portion A, and the second insulating base portion B is easier to bend. Also, since the first insulating base **10** including the antenna pattern **15** is thin, the distance between the antenna pattern **15** and a communicating counterpart, such as an antenna, located on the side of the first insulating base portion A is short, and the antenna device **7** has good communication performance. The flexible first insulating base **10** is easy to follow the shape of an article, for example, a case to which the antenna device **7** is attached (to which the first insulating base **10** of the antenna device **7** is bonded). Moreover, there is no risk that the conductor wires **31** and **32** are displaced and/or broken.

Fifth Modification to Seventh Preferred Embodiment

The antenna device **7** according to the seventh preferred embodiment can be also modified as illustrated in FIGS. **38** and **39**. In the modification illustrated in FIGS. **38** and **39**, at and around the contact portions where the antenna pattern **15** is connected to the conductor wires **31** and **32**, a ferrite sheet **192** is stuck on the upper surface of the second insulating base **30** via an insulating adhesive layer **191**. With this arrangement, the connection between the antenna pattern **15** and each of the conductor wires **31** and **32** is secured. Also, the ferrite sheet **192** is located over the cut **25***a* of the ferrite sheet **25**, and the magnetic field of the whole antenna pattern **15** is strengthened.

Antenna Device According to Eighth Preferred Embodiment

In an antenna device **8** according to an eighth preferred embodiment of the present invention, as illustrated in FIG. **40**, the conductor wires **31** and **32** are arranged in the second insulating base portion B so as to overlap with each other in the thickness direction (in a planar view). Specifically, the conductor wire **31** is provided on the base plate **30***a*, and the conductor wire **32** is provided on the base plate **30***b*. Further, a resist layer **190** is provided on the base plate **30***b* so as to cover the conductor wire **32**. As illustrated in FIG. **41**, an end of the conductor wire **31** is connected to the electrode portion **31***a* located on the lower surface of the base plate **30***a* via an interlayer connection conductor **186**. An end of the conductor wire **32** is connected to the electrode portion (**32***a*) located on the lower surface of the base plate **30***a* via an interlayer connection conductor although it is not illustrated in FIG. **41**. The other end of the conductor wire **31** is connected to the terminal **31***b* located on the upper surface of the base plate **30***b* via an interlayer connection conductor **185** formed in the base plate **30***b*.

The other portions of the eighth preferred embodiment preferably have the same structure as the seventh preferred embodiment and the modifications thereto. In the structure, as described in connection with the seventh preferred embodiment, in the outermost portion of the antenna pattern **15** and in the conductor wire **31** located closest to the outermost portion of the antenna pattern **15**, currents flow in opposite directions as indicated by arrows f and g. Therefore, a magnetic field generated from the outermost portion of the antenna pattern **15** and a magnetic field generated from the conductor wire **31** located closest to the outermost portion of the antenna pattern **15** are in the same direction inside the magnetic member (ferrite sheet **25**) and are not offset by each other. Therefore, degradation of the antenna characteristics is prevented. Further, the antenna device **8** according to the eighth preferred embodiment has the same effects as the antenna devices **5** and **7** according to the fifth and the seventh preferred embodiments.

In the following, some preferred examples of the position/configuration of the ferrite sintered body is described. FIGS. **42** and **43** illustrate a first example, which includes a first insulating base portion A including a spiral antenna pattern **15** having a first end **15***a* and a second end **15***b*, a second insulating base portion B including at least two conductor wires **31** and **32**, and a magnetic member **200** provided between the first insulating portion A and the second insulating portion B.

The conductor wires **31** and **32** are electrically connected to the first end **15***a* and the second end **15***b*, respectively, of the antenna pattern **15**. The magnetic member **200** includes a sintered body **201** of a magnetic material and a supporting sheet **202** stuck on the sintered body **201**. The sintered body **201** is located on the side of the first insulating base portion A, and the supporting sheet **202** is located on the side of the second insulating portion B. Resin, such as polyethylene terephthalate, polyethylene naphthalate, polyimide, etc. may preferably be used as the material of the supporting sheet **202**.

The sintered body **201** is preferably made of a magnetic material such as Ni—Zn-based ferrite or the like, and breaks easily. Therefore, in order to prevent breakage of the sintered body **201**, the supporting sheet **202** is bonded to the sintered body **201** by an adhesive (not shown). Since the sintered body **201** is located on the side of the first insulating base portion A (that is, on the side of the antenna pattern **15**), the magnetic flux density of the antenna pattern **15** is heightened, and the antenna characteristics are improved. Also, since the supporting sheet **202** is located on the side of the second insulating base portion B, the magnetic permeability therearound is lowered, and the magnetic fields generated from the conductor wires **31** and **32** are prevented from interfering with the antenna pattern **15**.

An antenna device includes a first insulating base portion including a spiral antenna pattern including a first end and a second end, a second insulating base portion including at least two conductor wires, and a sintered body of a magnetic material provided between the first insulating portion and the second insulating portion. The two conductor wires are electrically connected to the first end and the second end, respectively, of the antenna pattern. In the sintered body, slits may be provided in a matrix such that, in areas near the antenna pattern, the slits extend parallel or substantially parallel to the directions of magnetic fluxes generated from the antenna pattern.

Since the magnetic sintered body breaks easily, the slits may be formed in a matrix preliminarily. In this regard, if the slits extend parallel or substantially parallel to the straight portions of the antenna pattern in an area near the antenna pattern, the slits block the magnetic fluxes generated from the antenna pattern, and the magnetic permeability is lowered. In order to prevent this problem, as illustrated in FIG. **44**, the slits **201***a* are formed in the sintered body **201** in a matrix so as to extend in directions f' parallel or substantially parallel to the directions of magnetic fluxes generated from the antenna pattern **15**. With this arrangement, there is no risk that the slits **201***a* block the magnetic fluxes generated from (the straight portions) of the antenna pattern **15**, and a reduction in the magnetic permeability is prevented.

The slits **201***a* may be pierced in the sintered body **201** from the front main surface to the back main surface. Alternatively, the slits **201***a* do not need to be pierced in the sintered body **201** and may be provided on either the front main surface or the back main surface of the sintered body **201**.

An antenna device includes a first insulating base portion including a spiral antenna pattern including a first end and a second end, a second insulating base portion including at least two conductor wires, and a sintered body of a magnetic material provided between the first insulating portion and the second insulating portion. The two conductor wires are electrically connected to the first end and the second end, respectively, of the antenna pattern. Slits may be provided in a matrix in the sintered body except for areas near the antenna pattern.

As illustrated in FIG. **45**B, when the sintered body **201** is bonded to the insulating base **10** including the antenna pattern **15** thereon, the slits **201***a* may be forced to become wider, thus resulting in a change in the magnetic permeability. In the third example, however, no slits **201***a* are provided in areas near the antenna pattern **15** as illustrated in FIG. **45**A. Therefore, there is no risk that the slits **201***a* are widened in areas near the antenna pattern **15**, and a reduction in the magnetic permeability is prevented.

Other Preferred Embodiments

Antenna devices and communication terminal apparatuses according to the present invention are not limited to the preferred embodiments above, and various changes and modifications are possible within the scope of the present invention.

For example, the ferrite sheet as the magnetic sheet is not indispensable. Instead of the insulating adhesive layer, a non-adhesive insulating layer may be provided. In this case, the non-adhesive insulating layer does not always need to cover the entire upper surface of the first insulating base. The non-adhesive insulating layer only needs to have at least a portion corresponding to the bridge **20***b* for insulation (see FIG. **1**), that is, a portion covering the area between the first end and the second end of the antenna pattern in a planar view.

In a case where the ferrite sheet and the insulating adhesive layer are not provided, it is preferred that the first insulating base is thicker than the second insulating base. If the first insulating base is thinner than the second insulating base, the first insulating base deforms relatively easily, and the characteristics of the antenna pattern and/or other elements are likely to change. For example, when the thickness of the second insulating base is within a range from about 50 μm to about 100 μm, the thickness of the first insulating base is set within a range from about 60 μm to about 200 μm.

The detailed structures and the shapes of the antenna pattern and the conductor wires can be designed arbitrarily. Preferred embodiments of the present invention are applicable not only to radio communication apparatuses for an NFC system of a HF band but also to communication apparatuses using other frequency bands, such as UHF bands, for example, and other communication systems.

The material used for connections between the first end **15***a* of the antenna pattern **15** and the electrode portion **31***a* of the conductor wire **31** and between the second end **15***b* of the antenna pattern **15** and the electrode portion **32***a* of the conductor wire **32** is not limited to solder, and a conductive adhesive or any other conductive material can be used.

As thus far described, preferred embodiments of the present invention are useful in an antenna device and a communication terminal apparatus, and preferred embodiments of the present invention achieves the advantages of manufacturing an antenna device without using via-hole conductors and of requiring merely simple wiring for connection to an external device.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. An antenna device comprising:

a first insulating base portion including an insulating layer and a spiral antenna pattern including a first end and a second end; and

a second insulating base portion including at least two conductor wires; wherein

the insulating layer and the second insulating base portion are separate and independent layers;

the insulating layer is configured to insulate the at least two conductor wires from the spiral antenna pattern and is provided between the first end and the second end of the spiral antenna pattern in a plan view;

the at least two conductor wires include electrode portions electrically and mechanically connected to the first end and the second end, respectively, of the spiral antenna pattern by a conductive material;

the insulating layer includes a cut or an opening configured such that before the conductor wires are connected to the spiral antenna pattern, at least one of the first end and the second end of the spiral antenna pattern is exposed toward the conductor wires through the cut or the opening;

the at least two conductor wires are connected to the spiral antenna pattern by the conductive material in the cut or the opening of the insulating layer; and

the second insulating base portion is more flexible than the first insulating base portion.

2. The antenna device according to claim **1**, wherein the second insulating base portion protrudes outward from the first insulating base portion in the plan view.

3. The antenna device according to claim **1**, wherein the insulating layer is an insulating adhesive layer.

4. The antenna device according to claim **3**, wherein

the first insulating base portion further includes a first insulating base and a magnetic sheet provided on a side of a main surface of the first insulating base; and

the spiral antenna pattern is provided on the main surface of the first insulating base.

5. The antenna device according to claim **4**, wherein the insulating adhesive layer has a smaller thickness than the magnetic sheet.

6. The antenna device according to claim **4**, wherein

the magnetic sheet includes a cut in a portion facing the first end and the second end of the spiral antenna pattern; and

the first end and the second end of the spiral antenna pattern are connected to the respective electrode portions of the at least two conductor wires by the conductive material in the cut of the magnetic sheet.

7. The antenna device according to claim **4**, wherein the insulating adhesive layer bonds the magnetic sheet to the first insulating base.

8. The antenna device according to claim 1, wherein the first insulating base has a smaller thickness than the spiral antenna pattern.

9. The antenna device according to claim 1, wherein a cross section of the spiral antenna pattern is trapezoidal.

10. The antenna device according to claim 1, wherein
the second insulating base portion includes through holes; and
solder defining the conductive material for connection between the spiral antenna pattern and the conductor wires is filled in the through holes.

11. The antenna device according to claim 1, wherein at least a portion of the second insulating base portion including connection portions between the conductor wires and the spiral antenna pattern is coated with a resin material.

12. The antenna device according to claim 11, wherein
a through hole pierces through one or both of the first insulating base portion and the second insulating base portion from a front surface to a back surface; and
the resin material is filled in the through hole.

13. A communication terminal apparatus comprising:
an antenna device; and
a printed wiring board; wherein
the antenna device includes:
a first insulating base portion including an insulating layer and a spiral antenna pattern including a first end and a second end;
a second insulating base portion including at least two conductor wires; wherein
the insulating layer and the second insulating base portion are separate and independent layers;
the insulating layer is configured to insulate the at least two conductor wires from the spiral antenna pattern and is provided between the first end and the second end of the spiral antenna pattern in a plan view;
the at least two conductor wires include electrode portions electrically and mechanically connected to the first end and the second end, respectively, of the spiral antenna pattern by a conductive material;
the insulating layer includes a cut or an opening, such that, before the at least two conductor wires are connected to the spiral antenna pattern, at least one of the first end and the second end of the spiral antenna pattern is exposed toward the at least two conductor wires through the cut or the opening;
the at least two conductive wires are connected to the spiral antenna pattern by the conductive material in the cut or the opening of the insulating layer; and
the second insulating base portion is more flexible than the first insulating base portion; and
the printed wiring board includes at least a noise filtering section and a matching section; wherein
at least one of the conductor wires included in the second insulating base portion is connected to the noise filtering section or the matching section.

14. The communication terminal apparatus according to claim 13, wherein the second insulating base portion is folded back to connect the spiral antenna pattern to the noise filtering section or the matching section.

15. The communication terminal apparatus according to claim 13, wherein the second insulating base portion protrudes outward from the first insulating base portion in the plan view.

16. The communication terminal apparatus according to claim 13, wherein the insulating layer is an insulating adhesive layer.

17. The communication terminal apparatus according to claim 16, wherein
the first insulating base portion further includes a first insulating base and a magnetic sheet provided on a side of a main surface of the first insulating base; and
the spiral antenna pattern is provided on the main surface of the first insulating base.

18. The communication terminal apparatus according to claim 17, wherein the insulating adhesive layer has a smaller thickness than the magnetic sheet.

19. The communication terminal apparatus according to claim 17, wherein
the magnetic sheet includes a cut in a portion facing the first end and the second end of the spiral antenna pattern; and
the first end and the second end of the spiral antenna pattern are connected to the respective electrode portions of the at least two conductor wires by the conductive material in the cut of the magnetic sheet.

20. The communication terminal apparatus according to claim 17, wherein the insulating adhesive layer bonds the magnetic sheet to the first insulating base.

* * * * *